METHODOLOGY FOR MEASURING THE EFFECT OF MANAGEMENT ON CONSTRUCTION LABOR PRODUCTIVITY

William Wallace Collins

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by

WILLIAM WALLACE COLLINS
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Submitted to the Department of Civil Engineering on May 12, 1977 in partial fulfillment of the requirements for the degree of Master of Science in Civil Engineering.

ABSTRACT

Much superstitious learning exists in developing management strategies for improving construction labor productivity. To create an ability to plan and assess rational improvement strategies, the need exists to develop a methodology for measuring and analyzing the effect of management actions on labor productivity divorced from changes in technology and building methods.

This thesis focuses on the utilization of a simplified model of specific building operations in order to recognize basic influences of management on labor productivity. By making continuous on-site observations of many jobs of the same building operation with differing levels of management, the effect of management actions on labor productivity can be determined using graphical or regression analysis. By modeling the building operation around one of its major activities that has a quantifiable labor input and work output, a variety of jobs can be compared in spite of their lack of similarity. It is suggested that by applying the measurable work rate of the model activity to the percentage of productive work, a labor productivity index can be derived and used for comparison.

Floor tiling was studied to develop and test the methodology. Although sufficient data was not accumulated in this case study to provide confidence for conclusions about probable impacts of various types of management actions on labor productivity, several trends were highlighted. The study indicated that labor productivity, even in a trade as simple as tile laying, can be improved 100 percent or better where work specialization, work supervision, on-site coordination, and long term pacing are employed and encouraged.

Thesis Supervisor: Robert D. Logcher

Title: Professor of Civil Engineering

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This thesis is founded on a large number of interviews with construction professionals who were told that interview information was confidential. They will not be identified individually. However, to all the floor layers in Boston and New York City along with their employers, supervisors, and clients who freely gave their time, I wish to express my appreciation.

A heartfelt thanks goes to the graduate students and instructors in the Construction Management Division who contributed their ideas and lent an ear to theories and ramblings throughout the project. A special thanks goes to Professor Raymond Levitt and especially Professor William Little for their long hours of exploratory discussions and critiques. Their discussions prompted ideas for a decade of thesis topics.

I wish to acknowledge and express my appreciation to my thesis advisor, Professor Robert Logcher, for his assistance in my thesis preparation, and enthusiasm for the construction program in general which contributed greatly to my education at M.I.T.

Finally, I want to formally thank my wife, Trish, for her support, ideas, and perspective during the months of research, investigation and drafting.

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CHAPTER ONE

INTRODUCTION

1.1 INTRODUCTION AND SUMMARY OF FINDINGS

The nature of the construction industry makes it susceptible to inaccurate and incomplete knowledge about the effect of management strategies on labor productivity.[1] This condition is propagated by an inability to document the effects of isolated management actions on labor productivity.[2] It is understandable that such difficulty should exist in the construction industry. Factors effecting labor productivity are never constant and vary from job to job.[3] In addition, construction contractors who deal with labor directly are generally limited in their ability to devote time and money to the formal assessment of management style and its influence on labor productivity. The inertia of not being able to assess or predict the effect of a management strategy then reinforces the notion that new or different strategies have little potential for success.

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[1] Arnold S. Judson, "New Productivity Improvement Strategies for the Engineering/Construction Industry," The Civil Engineer's Role in Productivity in the Construction Industry, Proceedings of Conference, Lincolnshire, Illinois, August 23-24, 1976 (New York: American Society of Civil Engineers, 1976), p.55.

[2] J.T. Dunlop and D.Q. Mills, "Manpower and Construction: A Profile of Industry and Projections to 1975," U.S. President, Report of the President's Committee on Urban Housing, Technical Studies Vol. II: Housing Costs, Production, Efficiency, Finance, Manpower, Land (Washington, D.C.: U.S. Government Printing Office, 1968), p.254.

[3] Chris Argyris, Integrating the Individual and the Organization (New York: Wiley & Sons, Inc., 1964), p.3.

The purpose of this paper is to establish a methodology for rationally assessing the effect of management actions on labor productivity divorced from changes in construction means and methods. As such the paper deals with two questions concerning improvements in construction productivity: 1) how does one go about quantifying the effect of the management/labor relation on labor productivity? and 2) what management controlled factors most affect labor productivity? Although it is unreasonable to believe one can definitely predict the total effects of management on labor productivity, it is not unreasonable to attempt a more detailed scrutiny of the magnitude of these effects. Certainly management styles and productivity improvement strategies can benefit from much more careful, in depth, examination.

A case study of vinyl asbestos floor tile laying was used to develop a methodology for measuring management's effect on labor productivity. The materials and process of installing vinyl asbestos floor tiling attracted the attention of the author as a simple, easily monitored building operation. As such it could be used experimentally for the development of a predictive methodology. The inherent advantages of selecting such a straight forward building trade, containing a basic activity largely independent of job conditions, were not fully appreciated until later in the study.

In the design of the methodology (see Figure 1-1) the identification and study of vinyl asbestos tiling as a building trade paralleled the identification of significant parameters effecting productivity and the data collection methodology. On-site observations of actual work and discussions with subcontractors, educators, and general contractors provided feedback on the relevance of selected study approaches and para-

The impact of this inaccurate and incomplete knowledge, or "superstitious learning",[1] as it is called, on labor productivity, is three-fold. First, superstitious learning hinders management/labor interactions in the field by promoting ineffective management strategies. It is noted that "idleness or low productivity on the job is largely a result of management effectiveness."[2] Second, it encourages building contractors to select less than optimum organization structures for construction operations, leading to inefficient use of manpower and subsequently to a loss of competitive advantage. "In the United States, labor is the most expensive resource used in construction; it is also unique in that it is the only resource customarily controlled in the field."[3] Third, the cumulative effect of inappropriate management engendered by superstitious learning exhibited throughout an industry affects national productivity. Decreases in national productivity lead to increased inflation, decreased real wages, and to a loss of world-wide competitiveness for American goods.[4]

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[1] Peter Lorange and Michael S. Scott Morton, "A Framework for Management Control Systems," Sloan Management Review, Vol. 16, No. 1 (Fall, 1974), p.294.

[2] Dunlop and Mills, op. cit., p.256.

[3] Henry W. Parker and Clarkson H. Oglesby, Methods Improvement for Construction Managers (New York: McGraw-Hill Book Co., 1972), p.40.

[4] U.S. Department of Labor, Bureau of Labor Statistics, Monthly Labor Review, (December, 1972), p.2.

DESIGN STREAM FOR DEVELOPING METHODOLOGY

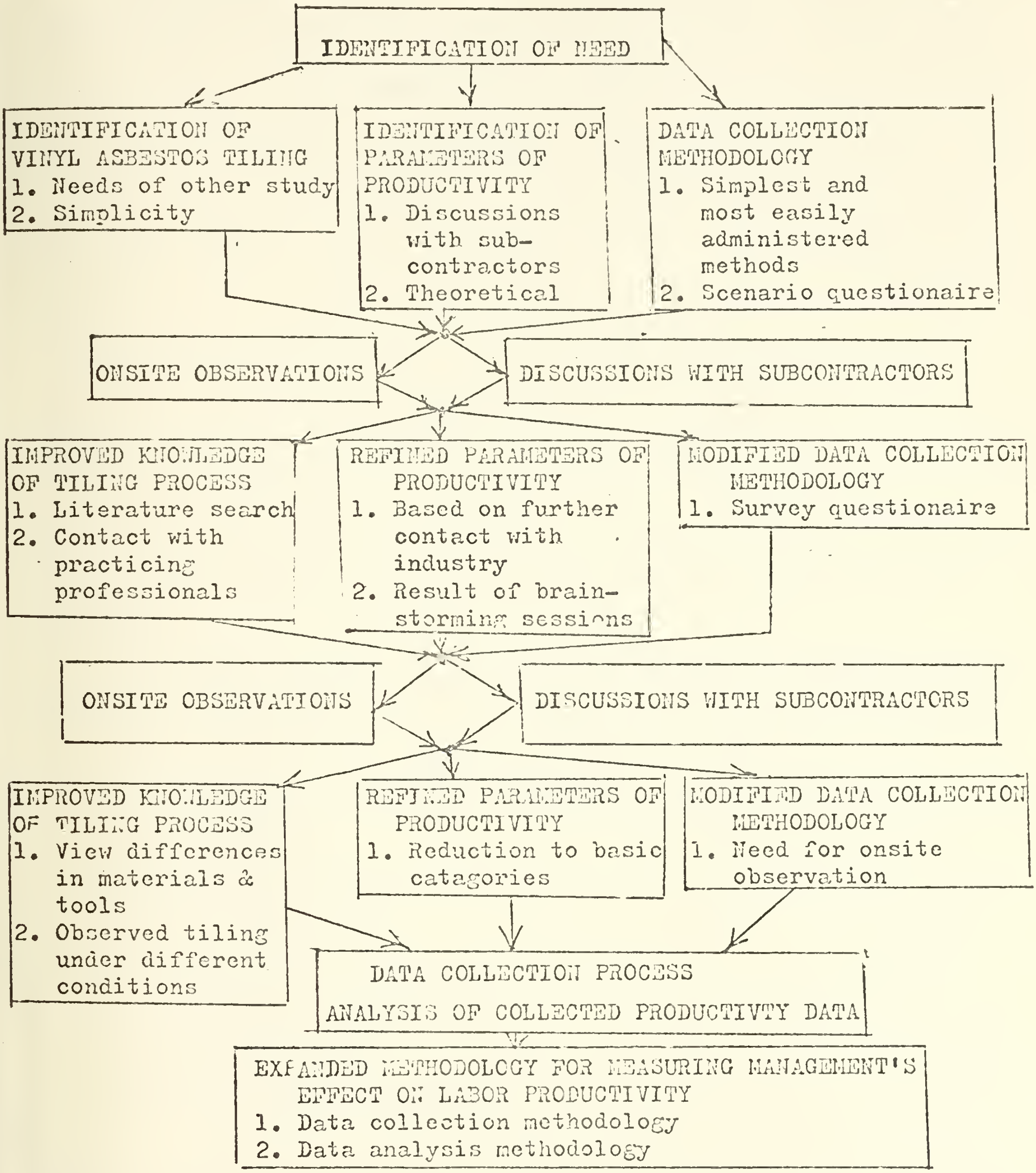

FIGURE 1-1

meters.

The terms "management", "labor", "productivity", "labor productivity" and "management actions" cover a multitude of meanings. For the purpose of this paper, however, they will have specific definitions. "Management" represents the person(s) of the general contractor or subcontractors that controls and directs the "labor." "Labor" means the person(s) of the work force actually performing construction work. "Productivity" is the "efficiency with which output is produced by the resources utilized."[1] "Labor productivity" is, then, the efficiency with which output is produced by the man hours of labor utilized. A "management action" is a decision initiated by management that impacts production. This thesis deals only with the effect of management actions on labor productivity. The effect of the means, methods, and materials of construction are not considered.

Of all the elements affecting labor productivity, the study indicates the importance of certain fundamental factors that management can control:

1) on-site management and coordination
2) job security
3) level of employment
4) long term pacing
5) management's expectation
6) worker seniority
7) office management problems

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[1] Jerome A. Mark, "Concepts and Measures of Productivity," The Meaning and Measurement of Productivity, Bureau of Labor Statistics Bulletin 1714 (Washington, D.C.: U.S. Government Printing Office, 1971), p.7.

1.2 VINYL ASBESTOS TILING CASE STUDY OVERVIEW

In order to 1) show clearly how this thesis evolved, and 2) spare others from making the same time-consuming explorations, a full description of the ineffectual approaches discussed in the case study to develop the methodology are included. The development and testing of a methodology for analyzing management's effect on labor productivity occurred as an iterative design process. The refinement of a methodology paralleled the testing of the methodology in the case study as pointed out in Figure 1-1.

Naturally, much time and many false starts were expended before the author 1) identified the problem precisely, and 2) arrived at a technique for solving it. The first two methods for collecting data were unrealistic in both their scope and expected accuracy. However, from their weaknesses, the need for on-site observations of work for the determination of labor productivity became apparent. Without recording exactly what happens, a reviewer of historical information is forced to rely on estimates from either uninformed personnel in the home-office, or hesitant workmen on the site. These shortcomings, along with the failure to realize the time constraints on subcontractor's time, yielded unusable data.

Growing out of the on-site observation technique was the concept of a labor productivity index. This, too, is in part due to the development of the methodology in a case study environment. Early on, it became apparent that job conditions greatly affect the differences in labor productivity. In order to assess the "true" productivity, a measure that precludes the job conditions is necessary. The effect of job conditions appeared to be even more pronounced than simple differences in building types (in general, subcontractors in tiling evaluate obtainable labor output in terms of the type of structure -- open areas as in a super-market

or department store versus a small room in an apartment versus broken areas in school rooms around tables and desks). Factors such as the location of storage areas for tools and materials, the presence of elevators, the congestion of various trades in the work area, the availability of snack bars, the particular differences in job requirements (e.g. clean the sub-surface or not), the area to perimeter ratio, and the like, all affected the typical rate at which a job would be completed. Certainly, all these factors are mixed in with the various management actions and tend to mask the effect of those decisions. The development of a model which would include and separate all such factors was felt to be too complex, and insufficient data would not be obtainable to calibrate it.

The ability to engage in on-site discussions with the workmen during breaks permitted further insight into the parameters of labor productivity. On all jobs there was a free exchange of ideas between the observer and the workmen.

1.3 SUMMARY OF METHODOLOGY

The case study itself evolved through more than one approach. The resultant methodology which this thesis proposes was generally developed in phase three of the case study, but since it had limited application, needs further testing to determine its weaknesses.

The methodology revolves around three basic assumptions. The first is that a standard identifiable model activity within a construction process can be found that represents the rate of work for the operation. Such an activity would have to be key to all other work and would have to extend through much of the operation. Secondly, the model activity must be capable of being isolated in time and place. Its rate of work as an isolated activity must not be affected by physical characteristics of the

job. The third assumption is that a determination can be made as to how much of the labor time expended on the job site was spent in productive work. Using these assumptions, a productivity index can be defined as the model activity work rate (in assumption two) times the percentage of total time on-site spent in productive work (from assumption three). This index represents total labor productivity on a particular job, and factors out physical differences.

Both predetermined management parameters and the productivity index can be determined for a particular job from continuous on-site observation periods of three to five days. If several jobs are observed an analysis of the management parameters and the resultant productivity index would allow a correlation of management action with productivity (remembering that means, methods, and materials are held constant). In addition to the productivity index, both the measure of work rate and percentage of time spent in productive work can be correlated to management actions. This does not provide any additional information about the effect of management on labor productivity, but does present information about the mechanism of changing labor productivity (changing work rate or changing percentage of time in productive work). The greater the number of jobs observed, the greater the significance of the results. If the number of jobs observed is less than the number of management parameters being considered, the analysis will give a family of possibilities rather than a reliable predictive model. In the case study five jobs were observed to evaluate ten parameters.

1.4 FACTORS AFFECTING THE RESULTS AND APPLICABILITY OF STUDY

Various methods for analyzing management actions on labor productivity were tested in a case of vinyl asbestos floor tiling. The study revealed that an accurate analysis of management actions and labor productivity on similar jobs requires continuous on-site observation over a period of several days. Such a data collection procedure has the following weaknesses: 1) the job may be affected by the presence of an observer on the job site, 2) it is difficult to assess the quality of workmanship achieved on a job, 3) one person is limited in his ability to observe all actions of an entire work force simultaneously, 4) there is difficulty in assessing the training effect inherent in continuous work, and 5) there is difficulty in finding a model activity that fulfills the requirements of the basic assumptions of the methodology as stated previously.

Any time an observer interacts with what is being observed, the observation is biased in some way. It was impossible to avoid interactions, however, between the observer and the workmen. The construction industry requires observers to move around a job site, and therefore the observer had to always remain close at hand to collect necessary data. An effort was made to minimize this "Hawthorne effect".[1] First, the independence of the observer from any management function or control was constantly re-emphasized. Secondly, an effort was made to fully integrate the observer with the work crew. All workmen were addressed as their peers addressed them (when observer talked with them). The manner of dress and grooming

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[1] Frederick Luthans, Organizational Behavior (New York: McGraw-Hill Book Co., 1973), p.29

was selected so as not to reflect a management image, and more closely copy that of the workmen. Thirdly, the observer did not attempt to control the conversation although his interest in individual and group motivation was expressed, and comments from workmen were appreciated. Fourth, an effort was made to minimize obvious note taking, or timing. The observer attempted to observe the work from a remote station when possible or to take notes about the work only when a workman's back was turned. In addition, every opportunity was exploited that reinforced the idea that the observer was naive to the trade and was basically interested in the mechanics of floor laying and not the labor productivity per se.

Since all workers need to be followed simultaneously, the observer was not able to record every action of all the workers. On the jobs observed in the case study, the observer was generally able to locate a central position among the work that allowed continuous observation of all parties involved. On the small localized office renovation jobs, there is a 95 percent confidence level that errors in observations account for less than .1 of a man hour per man day, or less than 1.4 percent of the total time of on-site observations. On the larger jobs that had larger work crews (Job #3 and Job #4), there is a 95 percent confidence level that errors in observation account for less than .3 man hours per man day, or less than 3.2 percent of the total time on on-site observations.

There was no way of testing the quality of the work observed. In order to account for the differences in quality a follow-up survey would have to be made to determine how much work was rejected by the client. The job type determines to a large degree the quality required. On office renovations the quality must be better than on large open floor areas. The quality of workmanship was generally observed to be equivalent on

similar jobs.

An adjustment to the work rate on Job #1 was made prior to analyzing the data. This step was taken to reduce the number of management parameters being considered in the case study. Job #1 was peculiar from the other jobs in that the workers, although Union carpenters, were not full-time tile layers. There is a well documented training effect that comes from "routine gathering" after a skill level is achieved.[1] An adjustment factor was, therefore, applied to the work rate of Job #1 that attempted to account for this effect. The percent-increase of local flooring subcontractor's quoted average output per man day over the average output estimated for a similar job in a standard estimating handbook, gave a rough estimate of the increased work rate achievable by the subcontractor who specializes in resilient floor tiling. Such an adjustment would not be made where the number of jobs observed was large enough to allow analysis of this parameter. By using the adjustment on this case study, trends could more easily be assessed. (All graphs incorporating this adjustment mark Job #1 with an "x" with an "o" for other jobs). In addition to the adjustment factor, another assumption was made to reduce the number of variable management parameters being assessed in the case study. The basic skill level of all workers whether apprentices or journeymen was assumed to be equivalent. All apprentices on the observed jobs had greater than one year practicing experience. Although that is not enough experience to enable them to organize and layout a job on their own, interviews with

[1]Marvin Gates and Amerigo Scarpa, "Learning and Experience Curves," Journal of the Construction Division, ASCE, Vol. 98 (March, 1972), p. 85.

subcontractor's and learning curve tables indicate that within three months an apprentice should have the skill level necessary to perform all basic functions.[1] As with the adjustment factor this assumption can be dropped and assessed independently given a large enough information sample.

As was stated previously, the methodology is dependent on the idea that a model activity can be found that is easily measurable and that represents the building operation as a whole, and that the percentage of total time spent in productive work can be determined. In very diversified building trades such as carpentry or electrical work, a standard activity may not be identifiable, and time spent in problem solving efforts is difficult to categorize as whether it is productive or not. For this reason this methodology might be best suited for building operations such as vinyl asbestos tiling. This does not diminish the value of such studies, however, as building blocks for general principles applicable to other more diversified building trades. Certainly it is not uncommon to find management deducing techniques of management from a trade or operation other than their own. Principles derived from the effective study of management techniques of a particular building operation can be enlightening when applied to another if interpreted judiciously.

In summary, the objective of the proposed methodology is to provide management with a clearer model of the effect of its decisions on labor productivity. With such a model decision-makers can predict attainable productivity levels, and assess the impact of current management strategies. Such assessments would permit rational improvements to construction

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[1] Ibid, p.83.

organization, management, and economics. By extension, the principles derived from revised management strategies may be applicable to various fields where management/labor interactions play a crucial role in the total productivity equation.

CHAPTER TWO

LABOR PRODUCTIVITY ANALYSIS TECHNIQUES

2.1 INTRODUCTION

There is an old maxim in the profession of construction management which maintains that "the tool hopefully will work, the men often won't."[1] This adage expresses management's continuing concern for monitoring labor productivity. There are many factors influencing labor productivity, and the more complex the building construction, the more complex the factors. These factors include such variables as technological advances, construction methods, tools and equipment, as well as crucial management actions.

Of all these factors, it is management actions which directly affect labor's productivity.[2] It is management that must forecast, plan, organize, command, coordinate and control.[3] Labor productivity studies therefore reflect management action. However, effort is rarely made to isolate the effect of specific management actions on labor productivity. As a consequence, improvements in labor productivity are made as a result of manipulating multiple factors at the same time -- as the result of perceived changes in work conditions, work crew, and management philosophy. This shotgun effect further masks the effects of specific management actions and can lead to incomplete and inaccurate knowledge of labor productivity. For these reasons it is important to appreciate how management currently assesses its labor productivity.

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[1] J.B. Bonny (ed.), Handbook of Construction Management and Organization (New York: Van Nostrum Reinhold Co., 1973), p.19.

[2] Lawrence A. Bennigson, "TREND: New Management Information from Networks," Proceedings, Third International Congress on Project Planning by Network Techniques (Stockholm, 1972), p.2.

[3] Luthens, op. cit., p.65.

2.2 STATE OF THE ART IN LABOR PRODUCTIVITY ANALYSIS

There is no best measure of labor productivity. The selection of a method and measure for determining labor productivity is dependent on the reason(s) for analysis. Typically labor productivity is evaluated by one of three methods: 1) ratio comparison of the input labor man hours to either the construction cost or labor output, 2) direct comparison of actual work to estimated work, and 3) method analysis by direct observation of the work. Not all methods are appropriate for studying isolated actions of management on labor productivity.

The first evaluation procedure is a comparison between labor resources and construction cost in the form of a ratio. Periodically, various sources including the Bureau of Labor Statistics, prepares indices reflecting recent construction output per labor input for various types of construction in the private economy.[1] These are national and industry-wide indices of labor productivity. Typically, the Bureau of Labor Statistics uses the average paid on-site man hours and the average contract price for different types of construction over a given period of time to establish the index.[2] Although such an index is significant in projecting trends, it is of little value to management as defined in this thesis. The indices represent industry-wide trends, are dependent on good information and are divorced from an evaluation of what contributed to each factor (e.g. bad weather, labor strikes, competitive bidding).

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[1] Dunlop and Mills, op. cit., p.254, and Mark, op. cit., p.12.

[2] U.S. Department of Labor, Bureau of Labor Statistics, Bureau of Labor Statistics Handbook of Methods Surveys and Studies, Bulletin 1910 (Washington, D.C.: U.S. Government Printing Office, 1976), p.219.

Another measure of productivity compares inputs to output as seen in the methods of work sampling.[1] In such procedures, labor activity is assumed to be synonymous with productivity. Short random observation periods allow the collection of data concerning the work activity of a crew. This data is statistically extrapolated to yield a ratio of the time spent in productive work to the total time paid. Such a measure provides little information about how well or for what reason the crew was performing various activities. It assumes that the observer can quickly determine when an activity is productive, and that the observed time period is representative of an entire work day. This measure, therefore, fails to provide accurate enough information to assess management's impact on labor. Variations in the work sampling method are seen in the so-called: 1) five minute rating technique, 2) Productiviyy ratings, and 3) field rating.[2] In each of these procedures random observations of labor activity are made and data is collected in accordance with prescribed definitions of effective or productive work to arrive at an extrapolated measure of productivity. Each of these procedures are susceptible to the same weaknesses as work sampling and therefore fail as an appropriate measure of labor productivity for this study.

The second general technique for evaluating labor productivity is by direct comparison of work accomplished to an estimated time and budget. Such a comparison can be either formal or informal. Typically, at the

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[1]Parker and Oglesby, <u>op. cit.</u>, p.40.

[2]Parker and Oglesby, <u>op. cit.</u>, pp.46-56.

subcontractor level, labor productivity is informally monitored and evaluated by the field supervisor or the subcontract owner. The study of a work force compares operations with expectations from the observer's own experience. In a formal comparison, labor output over a given period of time is tracked by job cost accounting. Periodically the accumulated information is recalled and compared to the estimated work as shown in budgets, and on bar graphs, PERT charts or CPM schedules. With this information, management will model the work progress and take some form of corrective action if performance falls significantly below expectations. Both the formal and informal methods for tracking and analyzing productivity are dependent on accurate estimates and the ability of management to determine the progress of the work. These are not trivial problems. Estimates are at best approximations, considering job conditions, designed to focus attention on meeting a bid and not on maximizing productivity. Although work progress may be clearly defined at the start and end of an activity, it is hard to discern the intermediate steps. In spite of the fact that budget comparisons do not fully indicate how effectively labor is being used nor what factors are contributing to the observed labor productivity, it has some strong points. The informal on-site inspections do provide a limited evaluation of factors contributing to labor productivity by permitting direct contact with labor. Unfortunately, inferences from such observations assume that the observations are representative of the entire work day. And, although such formal or informal comparison of similar work may indicate changes in productivity, they do not present management with enough information to correlate these changes with specific management actions.

The third general form of evaluating labor productivity is by direct full-time observation of the work process. This type of evaluation can be further divided into macro and micro studies of the work. Crew balance sheets, flow diagrams, and process data are determined from macro-studies of the site layout and work flow using time lapse photography or continuous on-site observation.[1] These are designed to evaluate the flow of men and materials on the job site. Since two-thirds or more of all construction operations can be identified as materials handling, this is an important area of analysis for construction management, and relates labor productivity with management actions.[2] Each job is individually assessed depending on job conditions and work cycles. This technique provides useful information for improving labor productivity of a particular job where repetitions in building cycles occur. Such a study, however, requires a continuous observation and an accurate evaluation of when a particular cycle starts and ends. Where time lapse photography is used to accurately record the flow of men and materials, the full work area must be seen clearly at all times and all personnel must be capable of being tracked. This is particularly difficult on job sites where people move around a great deal. Although not the purpose of this study, these procedures mentioned previously are adaptable to improving construction means, material or methods on a particular job site.

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[1]Parker and Oglesby, op. cit., pp.93-109.

[2]John Norton, Construction Division, E.I. DuPont de Nemours & Co., stated in lecturing at Stanford University that 75 percent of construction was materials handling. According to George Deatherage (Construction Estimating and Job Preplanning, McGraw-Hill Book Co., New York, 1965, p.4), 85 percent of labor and machine time is materials handling.

In contrast to macro-studies which look at an entire job site, the micro-studies observation technique concentrates on individual work operations. Such studies start with time and motion studies.[1] In these studies each movement required of a worker to complete a task is identified and timed. A base-line rate for standard tasks is established and compared to other similar operations in evaluating productivity. Careful analysis of each sequence can provide information for technological labor saving innovations. An analysis of this type requires documented time and motion studies, an accurate timing device and procedure, and careful identification of all elements of an operation. Such an analysis isolates the operation being observed from the work environment and therefore provides little information on the impact of management actions except as management can provide improved tools and work methods.

Typically these measures of labor productivity are not used to measure management factors, but the basic ability of labor to perform tasks. Nevertheless, one can draw on the characteristics of these three methods of measurement to analyze management factors. Job cost accounting defines job activities and associates with each labor utilization. Work sampling minimizes job interference and models the activity on a limited observation period. Full time on-site observation techniques permit an in depth evaluation of job conditions and factors affecting labor.

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[1] Parker and Oglesby, op. cit., pp.65-69.

CHAPTER THREE

MANAGEMENT ACTIONS AFFECTING LABOR PRODUCTIVITY

3.1 INTRODUCTION

Management's actions and options can be divided into technical and non-technical solutions. The distinction between the two is important in this thesis. For the purposes of this thesis, management actions that change the means, methods, or materials of construction will be considered technical actions and will not be considered. Although labor productivity improvements have been made from the use of power equipment, new materials, pre-fabrication in concrete work, excavation, carpentry, mechanical trades and finishing trades (an example of technical management improvements), the typical contractor must work within the technical state of the art to effect labor productivity improvements. What he can most readily affect are the factors divorced from the means, methods, and materials of construction, although he obviously maintains a continuing interest in the potential improvement possible from technical innovation. It is, therefore, important that the potential impact of non-technical management solutions be distinguished from technological solutions.

This paper further narrows the study of management actions to consider: 1) the establishment of group and invdividual labor qualifications, 2) factors involving individual and group motivations, 3) the extent and presence of on-site management and coordination of the work, 4) management supervision, 5) delays, and 6) the work quality standards. These factors represent management actions that are manipulated frequently by management especially at the subcontractor level (hereafter they will be collectively called management actions). It is the purpose of this study to develop a process for weighting the effect of these factors.

The following descriptions of each of these factors is presented to indicate management parameters that should be considered in evaluating management's effect on labor.

3.2 LABOR CREW CHARACTERISTICS

One of the major concerns of management action on labor productivity is the selection of individual and group labor characteristics for a particular job. Ideally, management would like a hard working well-trained, cohesive labor crew capable of accomplishing the work efficiently and effectively at low cost. In establishing such a labor crew management is interested in both individual and group characteristics. Whereas Union work rules dictate that certain requirements are met in a labor crew (certain number of apprentices on the job, hiring of foreman after work crew reaches a specified size) within these parameters management is afforded the right to hire and fire until satisfied with the labor crew. In this manner and through management supervision (discussed later in this chapter), management can manipulate crew characteristics to a limited degree.

In establishing an effective labor crew, management is interested in both individual and group characteristics. Four items are of primary importance in selecting the desired characteristics of individual workmen. The aptitude of the individual for the work is paramount. Not only must the worker have the physical characteristics necessary to carry out assigned tasks, he must also have the educational and psychological aptitudes for the work. As an aid in determining these characteristics, the Department of Commerce has compiled a list of preferred traits for most construction trades.[1] Secondly, the individual must be in good

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[1] U.S. Employment Service, Estimates of Worker Trait Requirements for 4000 Jobs (Washington, D.C.: U.S. Government Printing Office, 1957).

physical health. Although this is not a problem usually in the United States, it is a problem in many other parts of the world.[1] The diet and extent of rest greatly affect the ability of a worker to perform for extended periods of stress. The third item of interest to management is the craft training of the individual. This is usually separate from his general education, and refers to his formal or on-the-job training. This type of training is roughly measured by the skill rating achieved and is commonly expressed in the designation of journeyman or apprentice. The length of time required to train a worker from the apprentice class to journeyman status is a matter of continuing research.[2] Average training times required to meet skill levels as a function of worker aptitude and minimum capabilities are tabulated on learning curve graphs.[3] Such graphs provide base-line information to the employer for determining reasonable training times for personnel. The fourth factor affecting an individual's characteristics is his experience gained from "routine acquiring" patterns as a result of repetitious activities. "Routine acquiring" experience is gained from performing a repetitive task after a worker achieves the equivalent of a journeyman's status and his labor output is considered normal. It results in revitalized learning, and is commonly expressed in the idea of division of labor or job specialization. "Routine acquiring" learning curve graphs (different from learning curve graphs) indicate that

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[1] Fred Moavenzadeh, "Building Operation and the Choices of Appropriate Technologies for Conditions Prevailing in Developing Countries," (Prepared for U.N. Center for Housing, Building and Planning, M.I.T., Cambridge, Mass., 1975) p.37.

[2] Gates and Scarpa, op. cit., p.81.

[3] Gates and Scarpa, op. cit., p.83.

the time required to perform a repetitive task is improved at a constant rate assuming no work stoppages or changes in working conditions.[1] This rate of improvement is linearly related to the logarithm of the number of repetitions.

In considering group characteristics three items are of primary importance in affecting labor productivity. The first is the crew size and make-up. The crew size is often a function of the requirements of the work contract. Critical path activities may require a large work crew in order to finish on schedule. In addition, the nature of the work as specified in the contract may require extensive manual labor. Management must ensure that within the crew there exists the skill level necessary to complete the job properly, and strive to balance the cost of higher skilled labor to the lesser cost of inexperienced labor. Jobs may, of course, require more skilled workmanship due to higher quality control specifications. Secondly, management is concerned with assembling a crew that works well together as a cohesive unit. This cohesion will be affected by factors that it can and cannot control. These factors include: 1) the establishment of an informal group organization, 2) the ability or desire of each crew member to identify with the crew, and 3) the extent of "reciprocal interdependencies" between various crew members.[2] Thirdly, the previous experience of a group working together is also important. Not only does this affect group cohesion, but it may also reduce coordination problems where the group leader has worked with the same crew before.

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[1] Gates and Scarpa, op. cit., p.87.

[2] Benningson, op. cit., pp.44-60.

3.3 MOTIVATION

Another concern of management action is the degree of individual and group motivation. Although the elements of motivation are not always quantifiable, they can often be obtained from behavior observation or direct questioning.

The factors that affect group movtivation are internal and external to the group. Internal factors revolve around the strength and presence of group norms, the cohesion of the group, and the group leader. Group norms and cohesion are tied to common activities, sentiments and interactions.[1] They may support or undermine management's goals.[2] To a large extent the effect of these group norms is a function of the group leadership.[3] External factors are group rewards (or punishment) for collective work, the size of the work group, the organizational structure, the nature of supervision and job content.[4] The external factors are more readily affected by management than the internal factors. Internal factors are not easily identifiable or even complementary to management objectives.

Individuals in the work force are also affected by internal and external factors. There are a variety of theories dealing with the relationship between motivation and work.[5] A common position states that

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[1] George Homans, The Human Group (New York: Harcourt, Brace & World, 1950).

[2] Robert A. Sutermeister, People and Productivity (New York: McGraw-Hill Book Co., Inc. 1963), p.34.

[3] Chris Argyris, Personality and Organization (New York: Harper & Row Publishing Co., 1957) p.207 and Frederick Luthams, Contemporary Readings in Organizational Behavior (New York: McGraw-Hill Book Co., 1972) pp.446-448.

[4] Sutermeister, op. cit., pp.23-25.

[5] M.S. Myers, Every Employee a Manager: More Meaningful Work Through Job Enrichment (New York: McGraw Hill Book Co., 1970). p.207.

the individual is motivated by a hierarchy of needs and a pattern of learning that affects the satisfaction of these needs. These needs can be categorized as physical, safety, social, self-esteem and self-actualization.[1] The internal factors that form the learning pattern for satisfying the needs are heritage, goal orientation, self-image, and reference group.[2] Externally, learning patterns for satisfying the needs of the individual can be affected by many factors including job recognition, the work environment, pressure of group norms, job content, personnel policies, and the leadership climate.

3.4 MANAGEMENT SUPERVISION

Management supervision of work is another concern of management action. This includes both the supervision within a work crew, and the overall supervision and coordination of the work crew in meeting management's objectives. The primary forces in management supervision are the on-site foreman or leadman (as he is sometimes called), and the field supervisor who acts as the intermediary between the home-office and the on-site leadman. Four items are important in regard to the selection of the personnel used to fill these positions and the manner in which they fulfill their tasks.

The first is the training and motivation of the authority figure that is doing the supervising. The field supervisor must be trained in the craft that he is observing in order to evaluate the progress of the work force and to enable him to coordinate the needs of his crew

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[1]Sutermeister, op. cit., pp.71-90.

[2]Sutermeister, op. cit., pp.17-22.

with other trades. The leadman must be thoroughly familiar with the trade and be capable of making decisions and answering technical questions that arise on the job site. Part of both the leadman and supervisor's formal or informal training should be directed towards communicating effectively with all members of the work force, and towards balancing the importance of the job with the needs of the personnel.[1] In addition, the supervisor and leadman must themselves be motivated to ensure that the work is done properly.

The second item in management supervision is the frequency of observations. Constant observation may tend to aggravate the work crew, and a complete absence of management presence by either the leadman or supervisor may imply to the work crew a lack of concern for their work.

Closely tied to the frequency of observation is the manner of observation. The factors here are: the duration, whether the observation was announced or expected, and whether it was formal or informal. Formal observation tends to disrupt work, as does a knowledge of the projected time of observation. The proper duration is dependent on what the supervisor or leadman intend to accomplish by visiting the site or work and the amount of labor time possibly lost due to the observation.

The fourth consideration in management supervision is the authority leverage of the supervisor and to a lesser extent of the leadman. The supervisor's authority to affect motivational factors in the group or individual is important in considering the affect of on-site observations.

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[1]R.R. Blake and J.S. Mouton, The Managerial Grid (Houston: Gulf Publishing Co., 1964), p.10.

If precedence is given to other control systems over supervisor visitation such as the information provided from operating logs, time cards, and written progress reports, the effect of the observation will be minimal. The speed at which the supervisor can affect the individual and group motivation is also significant in assessing the authority leverage.

3.5 DELAYS

The presence of delays in the work is a significant factor in management. Not only does it affect work stoppage, it affects the learning curve advantages of continuous work. Delays can be separated into intra-shop management-delays, inter-shop management-delays, and delays that are external to management control.

Intra-shop delays are delays that are caused by oversights or failures of the managers responsible for the work accomplishment within a shop. They include delays dictated by standard operating procedures, poor job definition, estimating errors, poor communication and coordination between home-office and job site, a lack of home-office administrative efficiency, a lack of shop experience in a particular type of work, and various delays resulting from the nature of the work on the job site (work area clean up, the preparation of tools, the preparation and movement of materials, intra-crew on-site management and coordination, the layout of the work, breaks, and preparation of work area to receive building material).

Inter-shop management-delays result from inconsistencies between interfacing management teams of different shops or one shop with a parent organization. These delays are caused by interference, a lack of needed on-site equipment and utilities, the failure of work areas to be prepared for work, and confusion over exactly what work is required to be accomplished. These causes of delay are affected by the extent of

delineation of responsibility between shops or management teams, the extent of joint preplanning and operational monitoring, the degree of inter-management interdependence, the presence and participation of responsible authority figures in the planning stages, and contractural motivation to encourage management coordination.

Delays external to any management controls include the effect of unpredictable weather or natural occurrences, current economic and social conditions such as strikes and social unrest, the effect of sickness and absenteeism, and the failure of tools or transporting equipment. In addition, interference on the job site among workmen on the same crew or other crews of a very short duration are often unpredictable and external to any management controls.

3.6 QUALITY OF WORK

Contractural agreements, reputational consequences, building codes, health inspectors, and the client's desires all contribute to the level of quality required on a job. When extra care is required in the work, improvements in labor output must often be tempered.[1] Where labor productivity is pushed to excede quality controls, management must accept the risk of having the work rejected and replaced at no additional income.

[1] K.G.B. Bakewell, How to Find Out: Management and Productivity (Oxford, England, Pergamon Press, 1966), p.2.

CHAPTER FOUR

CASE STUDY

4.1 INTRODUCTION

This section deals with the investigation of the productivity parameters as they pertain to vinyl asbestos tile laying. The research methodology and data collection process is analyzed as well as a specific labor productivity analysis of the jobs reviewed. In the collection of analytical productivity data, five actual vinyl asbestos tiling jobs were observed continuously for two to five days. In addition to these continuously monitored jobs, six other vinyl asbestos tile laying jobs were studied in discussions with contract owners. The results of this study indicate a positive correlation between daily work output and the extent of on-site management and coordination of the work, management expectations, and the pace to which each man has become accustomed.

Initially the case study was designed to determine optimum crew sizes for vinyl asbestos floor tiling under specific work conditions as a predictive model for productivity improvement. It was hoped that tables of such data would become algorithms for optimum labor productivity. However, large differences in labor rates on jobs of similar crew sizes, materials, methods of installation, and job conditions, indicated the impact of other management actions. The study was revised to quantify these effects.

4.2 NATURE OF THE STUDY

The primary goal of this case study was to establish a positive correlation between labor productivity improvements and affirmative management action. It was hoped that this would lead to predictive models for determining productivity attainment levels in vinyl asbestos tile laying and the parametric control necessary for each level. In this way a decision maker

would have a predictive model for estimating the impact of various management strategies on labor utilization. The study was not concerned with improvements engendered by changes in the means, methods, and materials of construction. However, where potential technical improvements were discussed in interviews, they were noted so as to make maximum use of the interview information. (See Appendix E) The study underwent revisions and is viewed in three phases: Phase one) preliminary inquiries and investigations, Phase two) first cycle data collection and analysis, and Phase three) second cycles data collection and analysis. As the study progressed it became apparent that the manpower, time, and, in fact, industry support was lacking to develop a completely analytical model of labor productivity as a function of management action. Sufficient data was lacking to draw conclusions from analytical data. Therefore, the project was modified to observe a few jobs closely, noting both the correlations of management action to observed changes in labor productivity and the comments of on-site labor personnel. It was hoped that this intimate involvement in the trade and the people on the job would provide insight into the relevant parameters of productivity in other trades. This methodology dictated a more subjective model of attainable labor productivity in vinyl asbestos tiling, but allowed a more general knowledge of labor productivity applicable to areas beyond vinyl asbestos tile laying.

The thrust of this case study and the interest in vinyl asbestos tile was not randomly chosen. First of all, an M.I.T. research project is aiding the Israeli Ministry of Housing in adapting U.S. building technology to lowering the cost of multifamily housing. The potential of technology transfer is planned to be demonstrated in actual construction of a multifamily housing unit in Israel in 1979 (or thereabouts). In exploring technical

innovations for Israel, it had been determined that vinyl asbestos tile might be an economically attractive substitute for the present use of precast terrazzo tiles. However, the economic comparison of alternatives in this and in other building trades was based on a knowledge of labor costs. There was a desire to know what labor productivity could be attained in Israel with U.S. technology and how the question of accurate labor cost estimating in international technology transfer could lead to questions about the amount of labor productivity controlled by management differences. It became apparent that an economically advantageous transfer of technology might fail where labor output could not also be transferred. Therefore, interest in vinyl asbestos tile and mangement technology transfer provided the initial motivation for the case study.

In addition to the above impetus for studying vinyl asbestos tile as opposed to other building materials, there was also the consideration that tile laying is a simple process, therefore, more easily modeled for predictive purposes. Daily work accomplishment can be measured easily and accurately. The process can be broken into a few basic operations. This would enable an observer to understand when "productive" work was being accomplished and, therefore, to track "productive" work. The crews are usually small -- one to four men -- allowing an observer to track the individual work operations of each man. Ease of observations would be further enhanced by minimal dispersion of personnel on the job site. Work would usually proceed in specific areas with all men in the same area. With this simplicity and the presence of standard Union labor training, shop profitability would be a function of management actions and the volume of work. In a sense, the management issues should be the only ones that distinguish one shop from another. Unfortunately, intense competition presented one complication to the case study. Since only

management actions competitive with market demands were re-enforced monetarily over time, a form of natural selection weeded out any strategies that failed. Therefore, the study could only measure the effect of parameters that already accounted for acceptable labor productivity. It could not show how badly management can destroy productivity. This would not, however, limit the study from noting what parameters are correlated to improved labor efficiency.

Phase one of the study was conducted in Boston, Massachusetts. Phases two and three were conducted in Boston and New York City, jointly. The significance of these locations are: 1) the availability of large as well as small vinyl asbestos tiling jobs in these cities providing contrasting management parameters, 2) previous contacts with general contractors in both cities who could provide letters of introduction, and 3) budget constraints on travel. The period of study was from July 1976 to February 1977. All work was the result of the author's own interviews and observations with two significant exceptions. On a trip to New York City, during the second phase of the study, an additional graduate student from the Department of Civil Engineering at M.I.T. assisted in making initial observations. In addition, one of the on-site observation periods (Job #1) in phase three was accomplished by an M.I.T. undergraduate from the Department of Civil Engineering to permit observation of two jobs occurring at the same time.

Each of the three phases is reviewed separately. In the discussion of each phase, the strategy, procedure, weaknesses, results, and conclusions is presented. Since the third phase is the culmination of the first two, it is reviewed more thoroughly.

4.3 EARLY INQUIRIES -- PHASE ONE

4.3.1 Strategy

In Phase one six different floor coverings were considered as possible building materials appropriate for in-depth study. The selection of which material depended on a preliminary analysis of comparative costs and properties. The six types of finished floors considered were quarry tile, terrazzo (insitu and precast), linoleum sheet, asphalt tiles, vinyl asbestos tiles, and flexible vinyl tiles. These specific floor coverings appeared most amenable to the flooring needs of the Israeli low cost housing project (hereafter called the Israeli Project).

The preliminary analysis of cost and properties came from a literature search and interviews with practicing professionals in the flooring industry. The literature search was organized to precede the interviews in order to optimize the time spent with practicing professionals. The literature search reviewed current publications on: 1) product description, 2) labor productivity, 3) construction estimating, and 4) construction industry organization (See Appendix A for bibliography of initial readings).

Along with the collection of product information, a study of the optimum crew sizes for the six types of floor finishes was considered. The strategy for assessing optimum crew sizes required a two cycle process. First, a small sampling of flooring subcontractors would be interviewed to discuss their trade and typical labor productivity rates. Then, after analyzing the information, simple job scenarios would be presented to a larger sampling of subcontractors in the Boston area aimed at identifying (for each scenario) optimum crew sizes under different levels of crew supervision, experience, and tool combination. This second step would be

accomplished in Phase two. It was felt that an average response could be formulated for the scenarios and a production function written from it relating the allocation of men and material. If successful, the scenario could be changed and the process repeated. Implicit in this strategy was the assumption that subcontractors knew the impact of their management actions.

The interview strategy centered around making contact with one or two cooperative general contractors in the Boston area. Through them, inroads would be made to interview estimators, and subcontractors in the trades of interest.

4.3.2 <u>Procedure</u>

A general understanding of the field was obtained from background readings (Appendix A) and interviews with a general contractor in the Boston area, a construction estimator, and three flooring subcontractors were arranged. The cooperation of all parties involved was excellent and the interviews were each conducted in single sittings in the interviewee's offices lasting from one to three hours. The estimator provided estimates of the cost and installation labor for the installation of the six materials. The three subcontractors, each specializing in the installation of different materials were then interviewed. Each subcontractor was asked six questions about the primary materials that he handled. These questions were:

1) What is the general method of installation?

2) What tools are required?

3) What tolerances are required?

4) What is the curing time and are there installation problems?

5) What materials are required on a typical job?

6) What estimates of labor work-rate do you use?

In addition, general comments pertinent to each building material and its installation were encouraged. These interviews were completed approximately two months after the start of Phase one.

Information related to methods of installation and tool requirements collected during Phase one were recorded on Scenario Interview Form 1 (Appendix B-1). A separate Scenario Interview Form 1 was prepared for each standard method of installation for each primary material. The information on this form could be summarized on Scenario Information Form 2 (Appendix B-2), and then used to facilitate second cycle interviews with subcontractors.

4.3.3 Results

Phase one provided four tangible results. Parameters and measures of labor productivity in floor finishing were identified. Standard installation practices were determined for the six floor finishes considered. An expanded bibliography and circle on contacts were made. Comments concerning the study as originally conceived were offered by practicing professionals.

The parameters of labor productivity of finished flooring were determined to be:

1) primary materials used
2) methods of laying floor
3) tolerances required
4) work force characteristics including training and experience of the men, size, supervision, and the effect of cyclic operations
5) tools used
6) interfaces with other building trades

7) coordination and control of material supply.

These parameters were determined to impact the following units of measure:

1) cost/ft^2

2) time to install/ft^2

3) quality of installation

4) material characteristics including sound control, appearance, resilience, freedom from slipperiness, and warmth of surface.

The initial reading material generally corroborated current cost information provided by the interviews. Additionally, it provided a vital preparatory set for further interviews and reading.

Comments from practicing professionals indicated a general skepticism of the scenario interview approach. They stated that differences in job conditions could radically change a subcontractor's strategy for management of a particular job that would be expressed in a scenario interview. As such, scenarios attempting to isolate average behavior would be imprecise and useless. These comments were recognized as valid later in the study.

Appendix B-3 is a summary of the information gathered from subcontractor interviews. For each of the 12 methods of installations listed in Appendix B-3 in column 2, a complete report was compiled of 1) the various tools and equipment combinations typically used, 2) the sequence of installation, 3) the building materials required, 4) the life-cycle cost of the installation, 5) tolerances of the subfloor surfaces, 6) the labor requirements for installation, and 7) the estimated materials and installation cost.

4.3.4 Weaknesses

Phase one had several shortcomings. The most profound was the constantly expanding scope of the project. Without clear project definition, time consuming tangential issues were explored. The effects of legal constraints and union agreements in labor productivity were researched as were the effects of consumer preferences on the cost of materials and labor. In one sense, however, this lack of focus was the strength of the study overall since it allowed the study to step out into new areas. The problem of scope was closely related to the lack of clear definition in the meaning of productivity. Since the parameters of productivity cover a continuum of issues ranging from technical innovations to human behavior, a lack of definition led to an expansive research effort.

Phase one was a design spiral. A cycle of synthesis and evaluation was constantly occurring. The problem with this was that information collected from an interview needed refinement after the interview. Several phone calls were made back to each subcontractor interviewed to clarify points that had been made. For the researcher, this was not a problem. However, it became taxing for the practicing professionals, and hindered efforts in Phase three to gain additional support for the in depth study without going through the general contractor again with new letters of introduction.

4.3.5 Conclusions

The following conclusions from Phase one were made:

1) If approached through the "proper" channels, flooring subcontractors have a great deal of available knowledge and information about their trade.

2) Early identification of project objectives and definitions were

found to be of paramount importance in shortening the investigation period.

3) Initial project objectives and strategy may have been unrealistic. The scheme of using job scenarios to elicit management judgement in the allocation of resources in the flooring industry was thought to be too time-consuming and based on inaccurate information.

4.4 PHASE TWO

Phase two was a period of analysis and refinement. The Phase one conclusion, that the utility of the scenario device was limited, proved true.

4.4.1 Strategy

The strategy evolution of Phase two was as follows. The Israeli Project selected vinyl asbestos as the primary flooring material of interest in their study. Therefore, a vinyl asbestos job scenario was prepared. The intention was to use this scenario to establish an average production function for a standard method of laying vinyl asbestos tile. This function would relate crew size, crew make-up, individual crew member experience, tools, and the extent of supervision. Prior to using this scenario extensively, a trial run with subcontractors not previously interviewed was made. The trial run was conclusive and unfavorable to using the scenario form. This led to a re-analysis of the data collection techniques and the parameters of productivity. The revised strategy called for the re-identification of primary parameters of productivity, and abandonment of the scenario approach to establishing a production function. Instead, data reflecting the level of various productivity parameters on actual completed jobs

would be collected by interviewing on-site and home-office personnel on the final day of an actual job. These parameters could then be compared to observed output. This allowed analysis of different vinyl asbestos tiling jobs and attempted to identify a production function for any vinyl asbestos tiling job. A survey questionnaire was needed for data collection. As with the scenario technique, a trial run was to be made with the new survey. With eight management parameters, it was determined that a minimum of 48 jobs would be necessary to provide statistical significance in linear regression analysis. In order to conduct the survey on 48 jobs, all vinyl flooring subcontractors in the Boston area had to be solicited for assistance. If these did not provide the quantity of jobs required, other sources had to be sought.

This approach attempted to isolate the effect of each parameter on the overall time required for a job. The analysis was dependent on accurate information of how much time was spent on various activities so that jobs could be comparable. As an alternative data collection process, an attempt was made to collect cost control or time accounting data for specific jobs from subcontractors. Not only would this be documented data, but it would permit an expanded search for trends without depending on the completion of the job during the time of the study.

4.4.2 Procedure

The vinyl asbestos job scenario was prepared. A trial run with three additional flooring subcontractors in the Boston area was conducted. Two of them preferred to conduct the interviews over the telephone while the third was interviewed at this office. As had been the case in Phase one, the subcontractors were told of the purpose of the study and any background questions were answered prior to the beginning of the formal interview.

The formal interview required the subcontractor to answer questions based on a fictitious job scenario. The job scenario was as follows:

"The subcontractor had just won a bid for putting asbestos tile in 300 apartment units. The units were in several four and five story buildings grouped together. Each apartment unit had 750 square feet of floor area to be tiled with vinyl asbestos tile and 250 square feet of coved base. The units were divided into four rooms of equal footage. The flooring subsurface was clean and ready for tile. There were no elevators. The standard tiling procedure would be followed of equalizing the area on all walls, then smearing with an emulsion adhesive, laying of the field, cutting in and fitting the edge, and installing the base. No major site work remained as an obstacle to work."

The subcontractor was asked the following and his responses were tabulated in the appropriate boxes on the Scenario Interview Form 2.

"1) How many journeymen, apprentices with one to four years of experience, and helpers (being apprentices with less than one year of experience) would be sent to the job site?

2) How long would the crew in question 1 take to finish one apartment?

3) Which of the standard tool combination would the subcontractor send his men out with?

4) How much would he supervise or have one of his field supervisors supervise the work?

5) What percent of the time would this crew with these tools and supervision be able to meet the specifications of the job without rework?"

The answers to questions 3 and 4 would locate his response in one of the nine boxes of Scenario Interview Form 2. The answers to questions 1, 2, and 5 would be recorded in column 1 of the appropriate primary box. Then, assuming the same tools and level of supervision, the subcontractor would be asked questions 2 and 5 again for various changes in the work crew (e.g. what if you: added one helper, or added one journeyman, or subtracted one journeyman?). This process of altering his original crew, tools, and supervision would be repeated for each of the other eight boxes. Each question would be prefaced by the assumption of what tools and super-

vision were to be used. The subcontractor would again answer for each crew alteration, his estimate of the answer to questions 2 and 5.

In each interview, the subcontractor stated that the background job scenario did not give a complete enough picture of the situation. Factors such as the pressure from the general contractor to finish by a certain time, the number of apartments ready at any one time, the number of other jobs that the subcontractor was working, and a multitude of unpredictable site conditions, made it impossible to answer the questions accurately. The impact of crew or supervision on the work rate was not known. The "seat-of-the-pants" approach to the job was typified by one subcontractor who said he would send two journeymen and two apprentices the first day, and then see how they did. All subcontractors stated that the tools were standard and purchased by each man. The two subcontractors interviewed on the telephone were suspicious of the motivation behind the study and were reticent to state specific work rates.

The vagueness of the scenario and the impact of "outside parameters" on the management of vinyl asbestos tile installation decisions forced a re-analysis of parameters of productivity being considered. The initial strategy was altered to discuss actual jobs rather than subcontractor's estimates of hypothetical ones. This led to the measurement of actual labor output and apparent parameters of productivity. Since the number of jobs needed for statistical significance in such an analysis is tied to the number of parameters evaluated, an effort was made to isolate only the significant parameters.

The revised strategy called for the analysis of actual jobs and therefore most assumptions oriented to comparing similar jobs had to be thrown out. The jobs would now have to be reviewed from the point of view

of being comparable. This would be accomplished by determining the time spent in "productive" work, productive work being defined as standard activities that make up vinyl asbestos tiling -- smearing floor with adhesive, laying field, installing edge, and installing base. Time spent in other activities would be sought in order to determine what percentage of total on-site time was spent in productive work. With this in mind, a survey instrument was produced to collect data on the parameters listed in chapter two.

After a trial interview with a local general contractor, all flooring subcontractors listed in the Boston Yellow Pages were called to determine if they laid vinyl asbestos tile. The ones that did were sent a copy of the survey instrument and a cover letter (Appendix C). Of the fifteen flooring subcontractors who laid vinyl asbestos flooring in the Boston area, four expressed an interest in the project. Of these, two stated they expected little work until the spring of 1977, and did not wish to participate. With the minimum of 48 jobs needed, other sources were required. With the assistance of a local general contractor, two additional subcontractors in Boston agreed to participate. Through a general contractor in New York City, an additional two more flooring subcontractors expressed an interest in assisting.

4.4.3 Results

The job scenario technique was rejected. Productivity parameters were more clearly identified. A different approach to collecting productivity data was established. The interviewer would go on the job site near the end of the job to discuss the job with on-site personnel and then after the completion of the job would discuss it again with the home-office management. In order to conduct this survey in a uniform manner, a survey instrument was developed (Appendix C) and amended after initial review by

practicing officials.

Subcontractor support for the survey and the cooperation in executing it was marginal. Although thirty percent of the subcontractors in Boston approached to assist in the survey expressed an interest in it, only fifteen percent volunteered assistance as requested. Through a general contractor this percentage was raised to thirty percent (four subcontractors). Ironically, these four subcontractors represent the four largest in the Boston area and therefore represent only the most successful shops.

Seven vinyl asbestos jobs were surveyed with the survey forms. The crew sizes varied from one to eight men. Two of the jobs were in New York City, and the rest were in Boston. The persons interviewed on the small jobs (one to three men) reflected an awareness of the job delays particular to their job, but did not know actual time lost due to the various delays. The foremen and field supervisor of the job that had more than three men were unsure (or unwilling to state) even what delays occurred. Estimates of the time spent in surface preparation, loading of the tiles to a certain floor, breaks, and management delays were guesses based on previous experience of other jobs. In addition, on large jobs only estimates of the floor area completed were available and these were based on early quantity take-offs or the number of boxes of tiles delivered to the site, both of which were at best estimates. Take-off sheets sometimes reflect the extent of the job before change orders, and the number of boxes of tiles does not account for waste or vandalism. Even on the jobs where total footage installed and total man hours expended is known, no accurate knowledge is available on how that time had been spent.

On the two very large jobs the field supervisor became angry at the questions and claimed that the interviewer was wasting his time. The

accuracy of his estimates on one job did not make sense and reflected a tendency to guess rather than cooperate. He stated that a certain job of 27000 ft^2 had required 56 man hours to carry the tiles up four flights of stairs. Later, he stated that another job of 9700 ft^2 in a building with three operating elevators that could be loaded from an underground parking lot had required 35 man hours to load tile up to the fourth floor. That would imply that while 482 ft^2 of tile (approximately 11 cases) could be carried up four flights of stairs in one man hour, only 277 ft^2 (approximately 6 cases) could be loaded to the fourth floor in one man hour by use of an elevator. It became obvious that reliance on the memory of the job foreman or his boss was not valid on larger jobs. For this reason the survey became a useless tool in analyzing productivity.

4.4.4 Weaknesses

Phase two had much to teach about what to expect out of a survey and what not to do. A clear understanding of the academic-professional interface was lacking. The persons being interviewed were busy and distracted by their own problems. Both the scenario questionnaire and the survey questionnaire required full attention of the interviewed party to obtain accurate data. It is unrealistic to expect flooring subcontractors to give up so much of their time (and therefore money) to answer questions for the interviewer. The questions asked also required a specificity of knowledge unavailable to the persons interviewed.

Specifically, the scenario questionnaire was too vague and left too much to the subcontractor's imagination. The questions that accompanied the scenario were far too extensive. There were 108 individual questions if the questionnaire was fully compiled. Not only was this too time consuming, but it was too trying.

The original hope of collecting enough information to justify the use of average optimum crew requirements was idealistic. The scenario's job conditions were perceived differently by different contractors and an average of all the estimates would be a comparison of apples and oranges. In addition, good answers to the scenario questionnaire would still require thoughtful research on the part of the persons being interviewed prior to the interview. This would be another demand on their time.

The survey questionniare was a poor tool. It also required the person interviewed to know exact details. The questions about the number of feet of paremeter, the number of square feet of surface area, and the amount of time lost in delays was vital. However, in not one interview were these figures known accurately by either the foreman or field supervisor. In each case, estimates were made based on general rules of thumb, not the particular job in question.

4.4.5 Conclusion

The following conclusions were made for Phase two:

1) The model of a rational manager behind every operation fails in the vinyl asbestos flooring business. The office bound field supervisor rarely knows what is happening on the job site. He follows a general algorithm of trying to keep the lead journeyman honest, and productive. When things go badly, he makes radical changes in policy.

2) Neither the field supervisor nor job foreman attempted to accurately assess how much time each man spent performing various functions on the job site.

3) Comparing different jobs is difficult unless an accurate knowl-

edge of the time spent in each activity is known. The scenario's questionnaire overlooked this completely by assuming that stan-- dard job conditions could be specified. However, very minor differences in job conditions -- such as the presence of intru- sions through the floor in the form of pipes or columns -- changed the edge work and therefore, total work time greatly.

4) Antagonism between the interviewer and interviewee developed in attempting to quantify the issues in management decisions. This may have been a function of the interviewee's embarassment in not knowing answers to questions or the fact that management information was considered a trade secret.

5) Cost control accounting data was present in many shops but was not available for analysis.

6) The interface between the academic world of inquiry and the business of construction is delicate. Working relations based on an understanding of reciprocity needed to be developed and maintained.

7) An analysis of productivity requires an exact knowledge of what is occurring on the job site. The only way this could be known was to observe exactly what happened.

8) Group discussions between two or more interviewers contributed to a better understanding of interview situations and problems.

4.5 PHASE THREE

4.5.1 Strategy

The data that the survey instrument had attempted to collect was relevant but had to be collected by continuous on-site observation.

To do this a measure of "true"productivity would have to be made in order to facilitate comparisons. By identifying a model activity for the entire operation that did not vary from job to job, the work rate for that activity could be a model of the work rate for the building operation. The work rate itself would be divorced from all job conditions except ones that would physically retard its function (e.g. area too confining to work in), and the effect of management actions. By noting the amount of time spent in productive work an overall labor productivity index could be determined. The labor productivity index would reflect all job delays and management pre-job planning. As such it would also reflect management's effectiveness in both organizing the work and planning for contingencies, as well as the effect of job interference and unforeseeable delays.

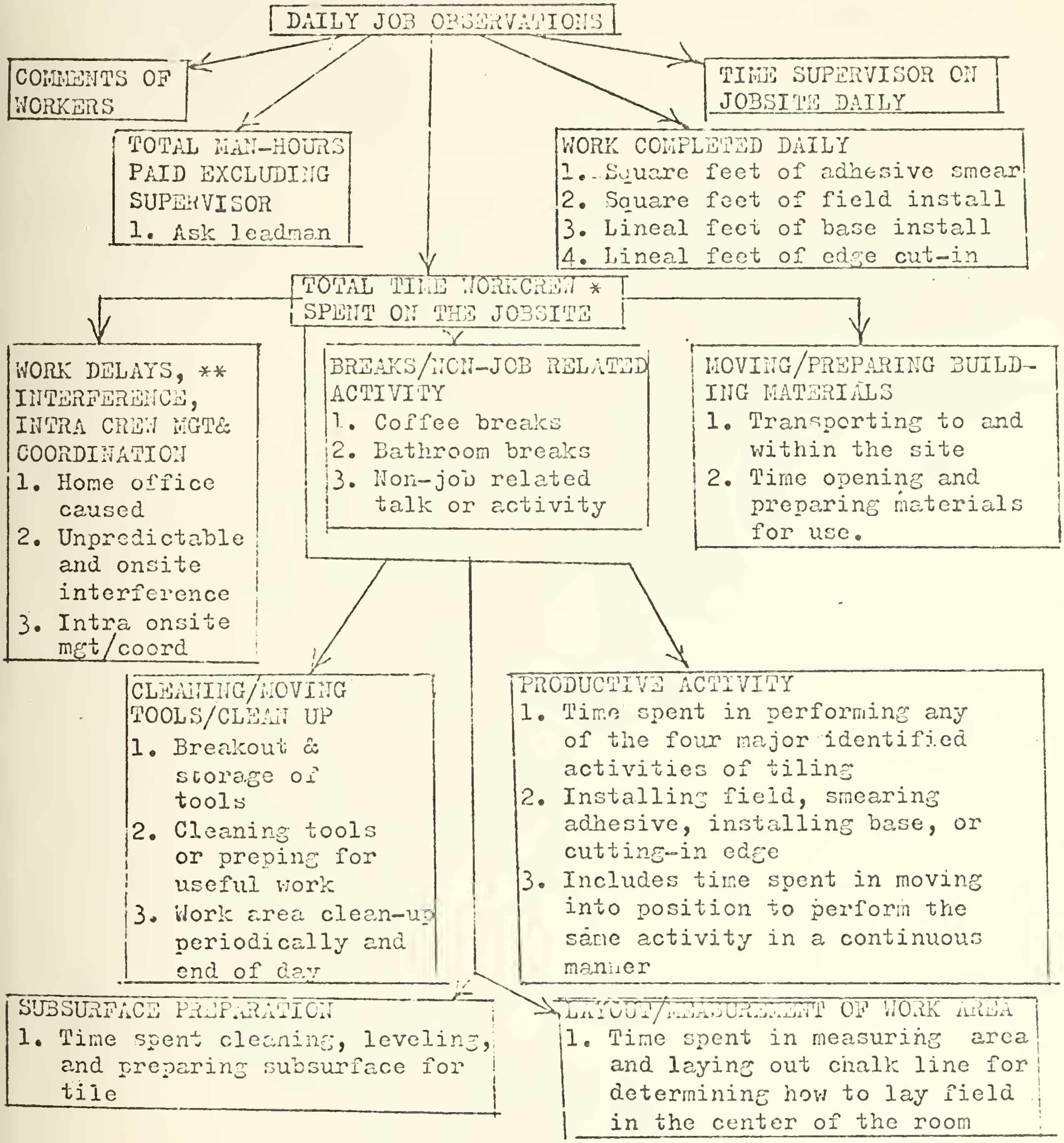
In order to achieve the information for the above strategy, the time spent by each man at each activity had to be noted and his progress calculated. By using on-site observations, his attitudes and motivation could be explored (to a limited degree), through direct questioning, and conversation. The job site had to be carefully measured off and all peculiar job conditions noted. The tools and materials used, the extent of supervision, and the job delays had to be followed. In addition, all this had to be recorded without getting a "Hawthorne effect".

To do this, it was planned that an observer would go on-site and record all identified management parameters and work rates in accordance with prescribed definitions. He would explain to all parties both on and off the job site that his intention would be to watch how the workmen laid

tiles and what delayed them. It would be made clear that information collected would be confidential and not critiqued to their bosses. Jobs would be observed for greater than three days, if possible, in order to gain the respect and trust of workers. An attempt would be made during coffee breaks and lunch breaks to get to know all workers, individually and as a group. Care would have to be taken to minimize or eliminate the workers knowledge that a written log was being kept. In every aspect of the job the observer was to remain passive and out of the way.

The actual data collected would indicate how much time had been spent in subfloor preparation, cleaning and moving tools, cleaning of work area, moving and preparing building materials, management coordination activity on-site among crew members, management caused delays, unpredictable delays, breaks, laying out of the work installation of the field, smearing of the adhesive, installation of the edge and base. Figure 4-1 and 4-2 diagram the observation to be made each day. The installation of field tile would be performed in an identical manner regardless of the job conditions, and would be a key activity in the tile laying operation. In addition, the quantity of work done in this activity could be easily measured at the end of the work day. As such, this process could serve as a model indicator or work rate for the entire building operation of laying tile.

HIERARCHY OF TERMS AND ACTIVITIES



* Activities requiring less than one minute were not recorded unless a very repetitive task (e.g. opening boxes of tiles). All activities were recorded on a Daily Progress Log (P1), and later catagorized in accordance with the definitions listed.

** A further breakdown of this catagory is presented separately.

FIGURE 4-1

FIGURE 4-2
HIERARCHY OF TERMS AND ACTIVITIES
FOR WORK DELAYS, INTERFERENCE, AND INTRA CREW MANAGEMENT ONSITE

ONSITE WORK CREW OBSERVATIONS

HOME OFFICE DELAYS

1. Man-hours lost that directly traceable to home office mgt
2. Failure of proper material to arrive onsite in a timely manner
3. Failure to have proper plans and specifications available to the leadman
4. Failure to arrange for proper onsite storage of materials and tools over night
5. Failure to coordinate with general contractor to ensure proper heat, light, ventilation, and interface with other trades so as to ensure work can start as scheduled
6. Distraction of crew members from working due to inspections of work, or standard shop operating instructions (e.g.—calling into the shop at the end of the day, or checking into the office prior to commence daily work).
7. Note, this catagory includes the time the leadman spends on the phone coordinating with his supervisor

ONSITE INTRA CREW MANAGEMENT AND COORDINATION

1. Man-hours lost due to management and coordination of onsite work by members of the work crew.
2. Time spent by leadman in making work assignments, controlling the pace and quality of work, and interfacing with other onsite trades and personnel
3. Time spent by any crew member in discussion of present or scheduled work onsite
4. Represents the cummulative time spent by the work crew in onsite management or coordination of the work

UNPREDICTABLE DELAYS AND ONSITE INTERFERENCE

1. Delays resulting directly from weather, equipment failure, power outages, emergency conditions (e.g. fire), sickness, and strikes are deemed unpredictable
2. Delays resulting from the interference of other trades in performance of work (as apposed to scheduling problems between trades which would be a home office delay), the interference of crew members working together so as to stop the work of one or more men, or delays caused by the failure of another trade to provide services as required

The possible parameters of management action can be separated into the effect on productive labor time and the effect on work rate. Figure 4-3 indicates the identifiable effects of management action on the work rate of installing the tile field. Figure 4-4 indicates how management affects the percentage of total time spent in productive work. The analysis of the collected data entails the adjustment of the work rate for labor experience if necessary and then the comparison of the jobs from the stand point of work rates, labor productivity index, the percentage of time spent in productive work, and the comments of the workers.

The number of jobs able to be observed were limited because of the requirement for extensive on-site observations. As a result statistical significance suffers. However, both the methodology and general trend can be established with only a limited number of observations.

Since differences in daily output was noted between Boston and New York City in earlier phases of the study, plans were made to review jobs in both cities. By going to New York City where bigger jobs exist, the opportunity was available to observe the effect of large crews.

4.5.2 Procedure

Having determined that laying of field would be the modeling activity, the identification and measure of the significant management parameters would have to be made prior to developing data collection forms. Figure 4-5 indicates the identified parameters.

Data collection forms were then developed (see samples in Appendix D). These forms include an initial site condition and layout sheet, an equipment and building materials storage location sheet, a progress log, and a daily completion report. Information from the daily log was transposed onto an Activity/Time Compilation Sheet for each man on the job

MANAGEMENT'S EFFECT ON WORK RATE
FOR VINYL ASBESTOS FLOOR TILING

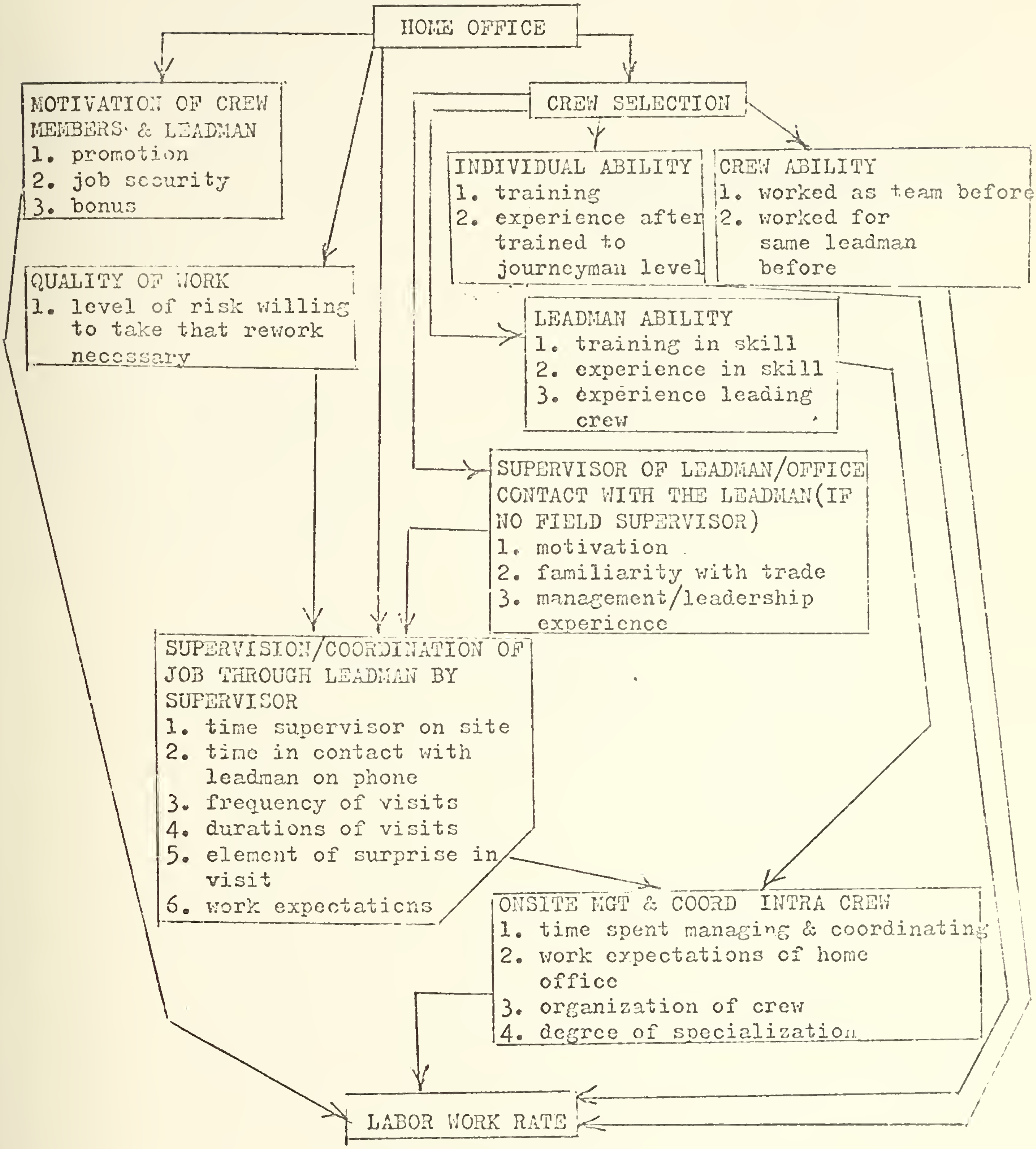


FIGURE 4-3

MANAGEMENTS'S EFFECT ON PRODUCTIVE LABOR TIME
FOR VINYL ASBESTOS FLOOR TILING

HOME OFFICE

HOME OFFICE COORDINATION & PLANNING TO AVOID JOB CONDITION DELAYS & PROBLEMS

1. ordering materials
2. interfacing with other trades & general super
3. storage facilities for material & tools
4. extent of surface preparation required
5. how field is to be laid out
6. inspection of site to ensure ready for tile
7. material delivery
8. supplying leadman with updated specifications
9. ensuring job requirements are known by leadman

DETERMINATION & DISSEMINATION OF STANDARD OPERATING PROCEDURES

1. extent of breaks
2. length of day
3. clean up requirements of job
4. smoothness of subfloor necessary before acceptable
5. who is responsible for unloading tiles at site and moving them to floor
6. number of breaks

PRODUCTIVE LABOR TIME

FIGURE 4-4

FIGURE 4-5
SIGNIFICANT VARYING MANAGEMENT PARAMETERS IDENTIFIED
AS EXISTING ON VINYL ASBESTOS TILING JOB OBSERVED

PRODUCTIVE LABOR TIME :

Parameter		Measure
1. Home-office coordination and planning in general	--	indirectly by evaluating % of total man hour delayed on job site to identifiable mistakes in planning
2. Breaks	--	% of total man hours on job site spent in breaks or non-job related activity

WORK RATE :

Parameter		Measure
1. Individual routine-acquiring experience	--	indirectly by adjusting non-regular tile layers work rate by the % increase of flooring subcontractors estimate of labor man hours required to complete a standard room as compared to the average rate listed for a tile layer in an estimating manual (since all journeymen equally trained)
2. Time supervisor on-site	--	average man hours he spends on-site per day
3. Time supervisor and leadman are in contact by phone	--	average man hours spent per day
4. Time spent in mgt & coordination on the job site among crew members	--	average man hours spent per day
5. Motivation of crew members and leadman in job security	--	present or not
6. Motivation of supervisor in terms of a bonus	--	present or not
7. Degree of specialization on job site in crew assignments	--	subjective
8. Degree of home-office expectation of work rate	--	statement of leadman
9. Established shop work pace	--	statement of "shop men" who have been with shop for several years
10. Interruptions in work activity	--	indirectly by using the % of total on-site man hours delayed for any reason

site each day. This information along with the Daily Completion Report was compiled on a Daily Summary Report (see Appendix E for a sample). The total work accomplished and the time used for each job is then tallied on the Job Summary Report for the entire job (Appendix E).

The actual jobs observed include (see Appendix E for fuller description): In Boston -- a) Job #1, an office renovation job worked by two Union carpenters from the maintenance division of a parent institution to which the office belonged and from which the workers were salaried. The job was observed for five days; b) Job #4, a new construction building with 20 foot by 20 foot open bays that was worked by three to four Union tile layers from a shop specializing in floor laying. The job was observed for five days. In New York -- a) Job #2, an office renovation job worked by one to four men who were all Union tile layers from a shop specializing in flooring. The job was observed for three days; b) Job #3, a new construction job with 30 foot by 30 foot open bays worked by five to eight Union tile layers from a shop specializing in floor laying. The job was observed for four days; c) Job #5, an office renovation job worked by one Union tile layer from the same shop as Job #2. The job was observed for two days. The same observer observed all jobs except Job #1. However, in order to standardize the observation procedure between the two observers, the observers spent eight hours discussing possible observation pitfalls and procedures.

Arrangements were made through the subcontractors and field supervisors to go on the jobs. On the first day of each job, the observer introduced himself to the leadman who had been informed previously of the purpose and time of arrival through the subcontractor. At the earliest opportunity, the entire crew was told by the observer that he,

the observer, was studying the techniques of laying tiles, and factors that interferred with such techniques. The observer learned each man's name and addressed him as his fellow workers did. On coffee breaks and at lunch time the observer would join the group discussions although usually only as a listener. Great care was taken so that the observer was dressed and groomed similarly to that of the workmen. Every effort was made to present the observer as supportive and unrelated to any management function or interest. Comments by the workers were encouraged. It was also stated that this was an independent study and that all information would be confidential and not given to the worker's emplcyer.

Each day at the job site was similar. The observer would arrive 15 minutes before the work was scheduled to commence. The site conditions including the extent of work previous accomplished were noted. When workmen arrived on the site, their time of arrival and initial activity were noted as well as the tools and building materials used. As each workmen changed their activity, the time and cause of change was noted on the Progress Log. An activity that lasted for less than one minute was neglected unless it was a repeated task such as opening boxes of tile. The time spent in an activity that had no relationships to the work was considered a break. When the field supervior came on the site to observe the progress or talk to personnel, his activities were also recorded. Management caused delays and management activities were separated into on-site management and coordination between crew members, and home-office caused delays. Included in the home-office management-delays was the time that the field supervisor distracted members of the work force, delays caused by the failure of the site to be prepared by other trades or

materials to be delivered, and delays that could have been avoided by more extensive but reasonable coordination with other interfacing building trades and officials. Productive work was defined as work composed of one of the four primary activities required to install vinyl asbestos tile: smear, install field, install edge, and install base.

At the completion of the day's work after the workmen had left, the observer noted the progress of the work over the entire day in each of the primary areas of work. The Progress Log was then analyzed for each man's work for the day by use of the Activity/Time Compilation Sheet that breaks down each man's work for the day into a time stream of activities. The individual work analysis was then compiled for the entire crew for an entire day on the Daily Summary Report. A collection of Daily Summary Reports for the job was compiled on the Job Summary Report.

The jobs were then compared in terms of the labor productivity index, the work rate, the percentage of time spent in productive work, and the comments of the workers.

4.5.3 Weaknesses

Phase three was highly successful. Its major shortcoming was in the limited sample size. Since only five jobs were observed for different lengths of time, the question of significance is relevant. Additionally, observations may not be representative of the most or least productive vinyl asbestos jobs. As was pointed out earlier, the very poor shops were automatically screened out of this type of study since they would not survive in the market. However, discussions with tile laying subcontractors in both Boston and New York indicated that Job #4 represented extremely fast tile laying.

The question of quality was not addressed in the productivity study. Certainly it would seem that a shop could lay tile faster at a rate inversely proportional to the quality of its work. Since quality is a subjective measure judged by the client, the time spent reworking a rejected job should be included in the observation. Unfortunately, this procedure was not possible in this case study for two reasons. One, the client's acceptance or rejection of the work occurs after the observer has left. Two, the acceptance of the work by a client is dependent on the type of work and who the client is. Renovation work in office space is more carefully checked than a large open expanse of work in a warehouse. The client can be a keen observer or can be absent from the site entirely. For this reason, only jobs with equivalent quality standards can be compared. This could further limit the sample size of the data collected.

The observer was only on the job site and did not know how much work the home-management had put into coordinating and planning. It was thought that the jobs with the fewest number of management caused delays reflected the shops that had spent the most home-office effort in preparation. In any case, the labor productivity index would not fully account for the effect of home-office management and planning. The amount of home-office planning was assumed in this study to be reflected in the number of observed home-office caused delays.

An observer's presence on a job site may disrupt the work rate. He may act as a motivator or distractor depending on how he is perceived by the workmen. There is no guarantee that this did not occur during this study. Similar attempts on all jobs were made to eliminate or minimize this "Hawthorne effect", but no compensation for such an effect was

applied to any of the data.

On several jobs there were more than three men working at one time. This meant that the observer had to follow different men at the same time. Although this was simplified by the fact that a man's work could be monitored from across the hall, inaccuracies in the record of actions were possible. All data was tabulated in tenths of an hour so that the time each man worked in each activity was rounded off to the nearest six minutes. On the small localized office renovation jobs, there was a 95 percent confidence level that errors in observations accounted for less than .1 of a man hour per man day, or less than 1.4 percent of the total time of on-site observations. On the larger jobs that had larger work crews, there was a 95 percent confidence level that errors in observation accounted for less than .3 man hours per man day, or less than 3.2 percent of the total time of on-site observations.

4.5.4 Results

Phase three provided two types of results. First, it provided information on the versatility and strength of the data collection methodology used. In this regard, it appeared that comparable data could be collected on jobs of different types. Secondly, the data and interviews used in Phase three provided insight into the parameters of productivity. Both of these results were looked at more closely.

Phase three methodology provided a subjective analysis as well as an analytical tool for measuring the labor productivity parameters effective on a job site. It allowed an accurate accounting to within ten minutes per manday of exactly how the labor force spent its time. It accurately measured the work accomplished each day. Spontaneous comments and activities were recorded. The classification of work activities and delays made

the measurement procedure uniform and consistent. In addition, knowledge of the trade and its problems were acquired firsthand by observation.

The Daily and End of Job Data Summary Sheets for the five jobs are included in Appendix E. Appendix D has a sample of an actual on-site observation for one day. Figures 4-6, 4-7, and 4-8 summarize the information collected from the actual observations. Figures 4-6, 4-7, and 4-8 are graphically compared in figures 4-9 and 4-18. In making comparisons between the different jobs, an assumption was made to reduce one of the parameters to a constant. The work rate for Job #1 was adjusted for the fact that it was the only job that did not have regular full time tile layers performing the work. Instead, Job #1 had Union carpenters trained in how to lay tile, but lacking in the routine-acquiring experience that comes from continuous repetitions of the same work. From statements of subcontractors interviewed and the literature on training times, it could be reasonably inferred that the training period for all apprentices observed was of sufficient length to state that they had enough training to qualify as journeymen in all phases of the work except the layout and organization of the work. By comparing the average work rate in Building Construction Cost Data [1] and the Building Cost File [2] for a typical vinyl asbestos tiling job with the estimate of the interviewed subcontractors who were specialists

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[1] R.S. Godfrey (ed.), Building Construction Cost Data (Duxbury, Mass.: Robert Snow Means Co., Inc., 1976).

[2] Building Cost File (Eastern Edition) (New York: Construction Publishing Co., Inc., 1976).

FIGURE 4-6

TABULATIONS OF OBSERVED LABOR INPUT AND PRODUCTIVITY

	JOB #1 hrs.* spent	JOB #1 % tot time	JOB #2 hrs. spent	JOB #2 % tot time	JOB #3 hrs. spent	JOB #3 % tot time	JOB #4 hrs. spent	JOB #4 % tot time	JOB #5 hrs. spent	JOB #5 %tot time
Manhrs Paid	68	100	22.5	95	128	98	175	93	14	94
Work delays and onsite mgt/coord time	10.9	16	2.5	10	7.6	6	14.5	8	1.8	12
Cleaning/moving tools andclean up of area	4.4	6	2.7	11	11.4	9	8.2	4	1.4	9
Breaks/non-job rekated activity	17.4	26	3.3	14	25.2	19	35.4	19	3.9	26
Moving/prep of build materials	4.6	7	1.1	5	8.3	6	32.3	17	.9	6
Layout/measure work of area	1.7	3	.1	1	2.3	2	5.1	3	.1	1
Subsurface floor preparation	1.6	2	2.7	11	7.1	5	2.2	1	.6	4
Productive work activity	27.1	40	11.4	48	68.6	53	90.1	48	6.2	42
Time spent in installing field	4.7	7	.9	4	16.6	13	38.6	21	.7	5
Home office caused delays	9.6	14	.8	3	3.1	2	5.5	3	.8	6
Unpredictable delays & onsite interference	.5	1	.3	1	2.0	2	3.3	2	.6	4
Intra crew onsite mgt/coordination	.8	1	1.4	6	2.5	2	5.4	3	.4	3
Average intra crew onsite mgt/coord per day	.19		.62		.5		1.35		.2	
Time leadman on phone giving status to supervisor	.0		.4		.8		.0		.2	
Time supervisor onsite	.8		.6		.5		3.5		.0	
Average time per day supervisor in contact with crew through phone contact with leadman or being onsite	.19		.44		.26		.875		.1	
Number of days of total that supervisor came onsite	4 of 5		2 of 3		2 of 5		3 of 4		0 of 2	
Number of days observer on jobsite	4.25		2.25		5		4		2	

* hrs. spent represents manhours spent at this activity for entire job.
% tot time represents % total time onsite spent in this activity.

FIGURE 4-7

TABULATION OF OBSERVED LABOR OUTPUT

	JOB #1	JOB #2	JOB #3	JOB #4	JOB #5
Floor area of work area — approx in FT^2	2300	900	45,600	50,000	2200
No. FT^2 of edge put in	520	420	730	2900	120
No. FT lineal of base put in	535	0	1720	0	570
No. of FT^2 of field installed	1720	770	11,030	45,230	450
No. of FT^2 of smear put in	2270	870	12,730	43,370	550
No. of FT lineal of perimeter bordering on tile work whether field or edge—approx	800	450	2500	2400	1000
Area to perimeter ratio in FT^2/FT	2.9	2.0	18.2	20.8	2.2
No. of paid hrs. work per full man day	8	7	8	7	7
Average no. of tile workmen on site per day	2	2	3	6	1
No. of FT^2 of field laid per man day paid	200	238	688	1806	224
Total man hours worked on job	67.7	23.8	130.5	187.5	14.9

FIGURE 4-8

TABULATION OF OBSERVED LABOR WORK RATE

	JOB #1	JOB #2	JOB #3	JOB #4	JOB #5	
No. FT^2 of field laid per total paid man-hours	25	34	86	258	32	
No. of paid manhours per paid man-day	8	7	8	7	7	
No. FT^2 of field laid per total paid man-days	200	238	688	1806	224	
No. FT^2 of field laid per man hour spent laying field (work rate)	366	855	665	1170	642	
Adjustment factor applied to work rate to adjust for experience curve	1.56	—	—	—	—	
Adjusted No. FT^2 of field laid per man hour spent laying field (adjusted work rate)	570	855	665	1170	642	
% of total on site time engaged in productive work	.40	.48	.53	.48	.42	
Labor productivity index for vinyl asbestos tiling	228	410	352	561	270	

in the field of finished flooring, an estimated learning effect on the part of the regular tile workers (specialists) of the subcontractor could be determined. The largest increase in work rate between these measures was 56 percent and, therefore, it was used as a conservative adjustment factor to account for the difference between Job #1 and the other jobs. This was based on the subcontractors estimate of being able to lay tile in a room with the edge and base at the rate of 580 to 750 ft^2/man day. The estimating manuals listed above indicated the average work rate was 480 to 520 ft^2/man day. By assuming that the carpenters on Job #1 were at the low end of the spectrum at 480 and the full time tile layers were at the high end, the difference represented a 56 percent increase.

The outstanding results were as follows:

1) The area to perimeter ratio affected the work rate of the model activity to a limited degree (Figure 4-9).

2) The differences between the job conditions as a function of unpredictable delays were small (Figure 4-6). The scatter around the straight line that correlates the work rate (nearly job condition free) and the labor productivity index (affected by job delays and conditions) indicated the jobs viewed were not significantly differentiated from each other by job conditions (Figure 4-10).

3) Work rate was correlated with the amount of average daily on-site intra-crew management and coordination (Figure 4-11). However, the sloping curve of Figure 4-12 indicated that the rate of improving overall labor productivity decreased with increased average intra-crew on-site management and coordination.

FIGURE 4-9

WOR RATE VERSUS AREA TO PERIMETER RATIO

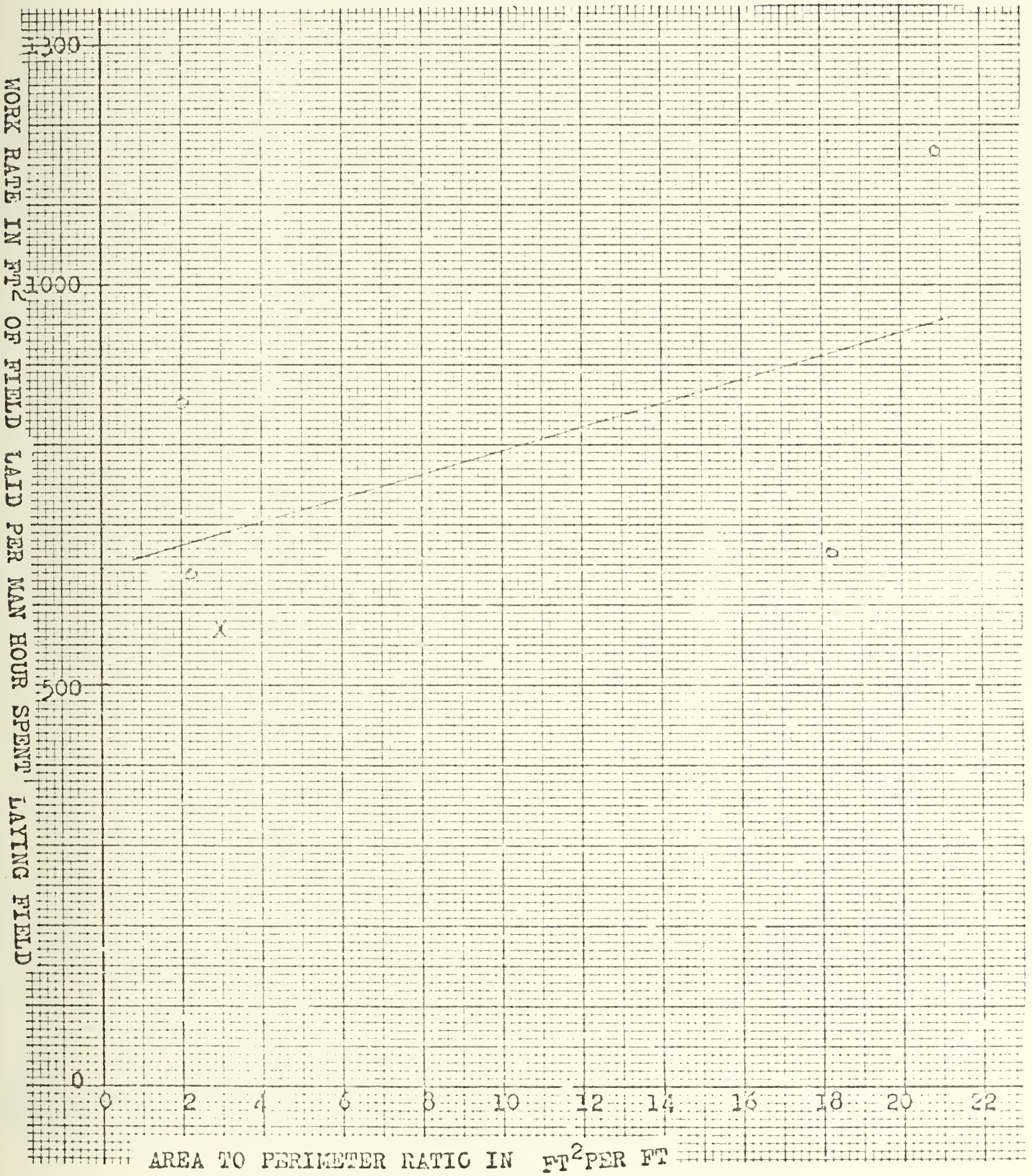


FIGURE 4-10

WORK RATE VERSUS PRODUCTIVITY INDEX

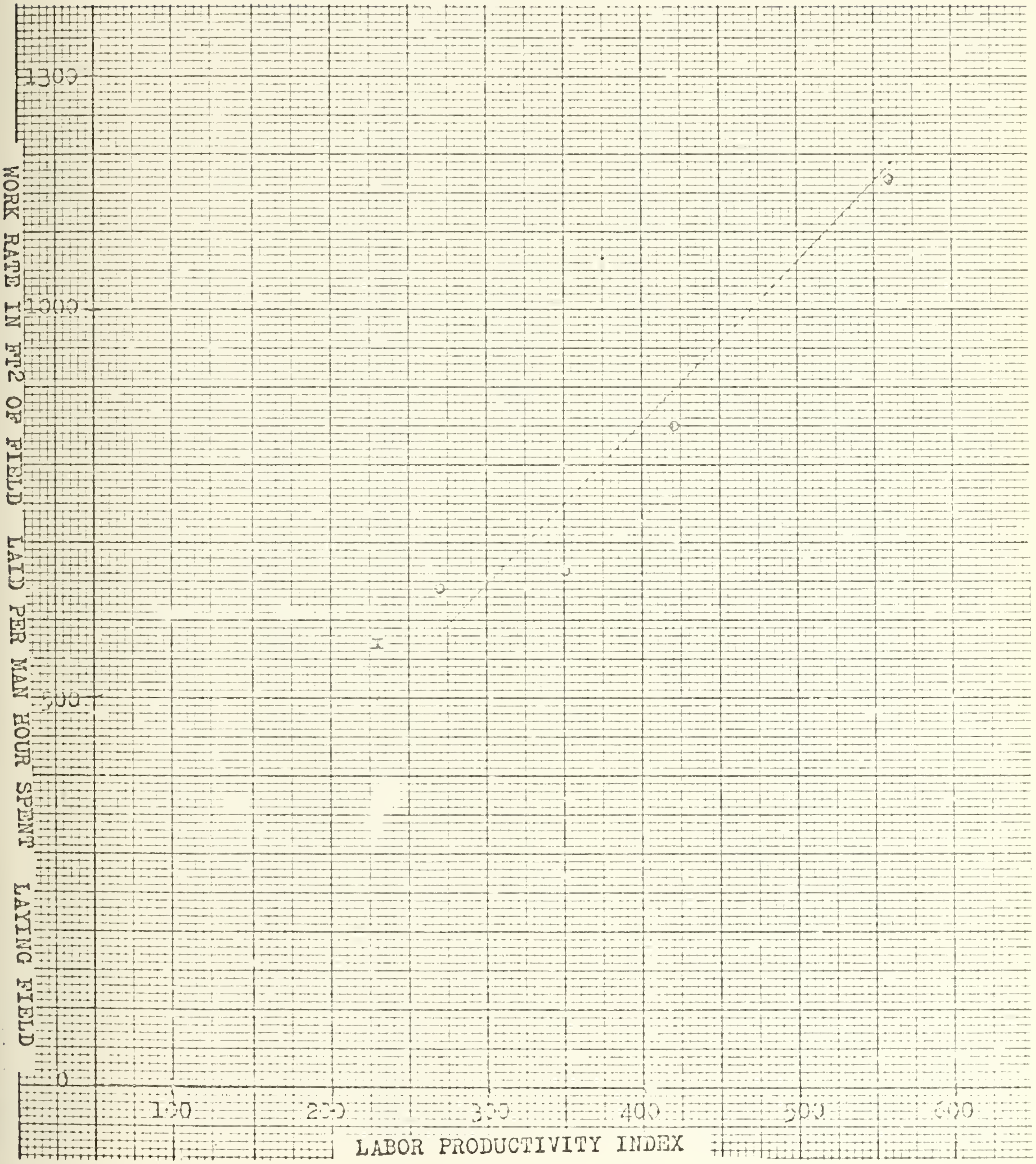


FIGURE 4-11

WORK RATE VERSUS AVERAGE DAILY INTRA-CREW MANAGEMENT AND COORDINATION

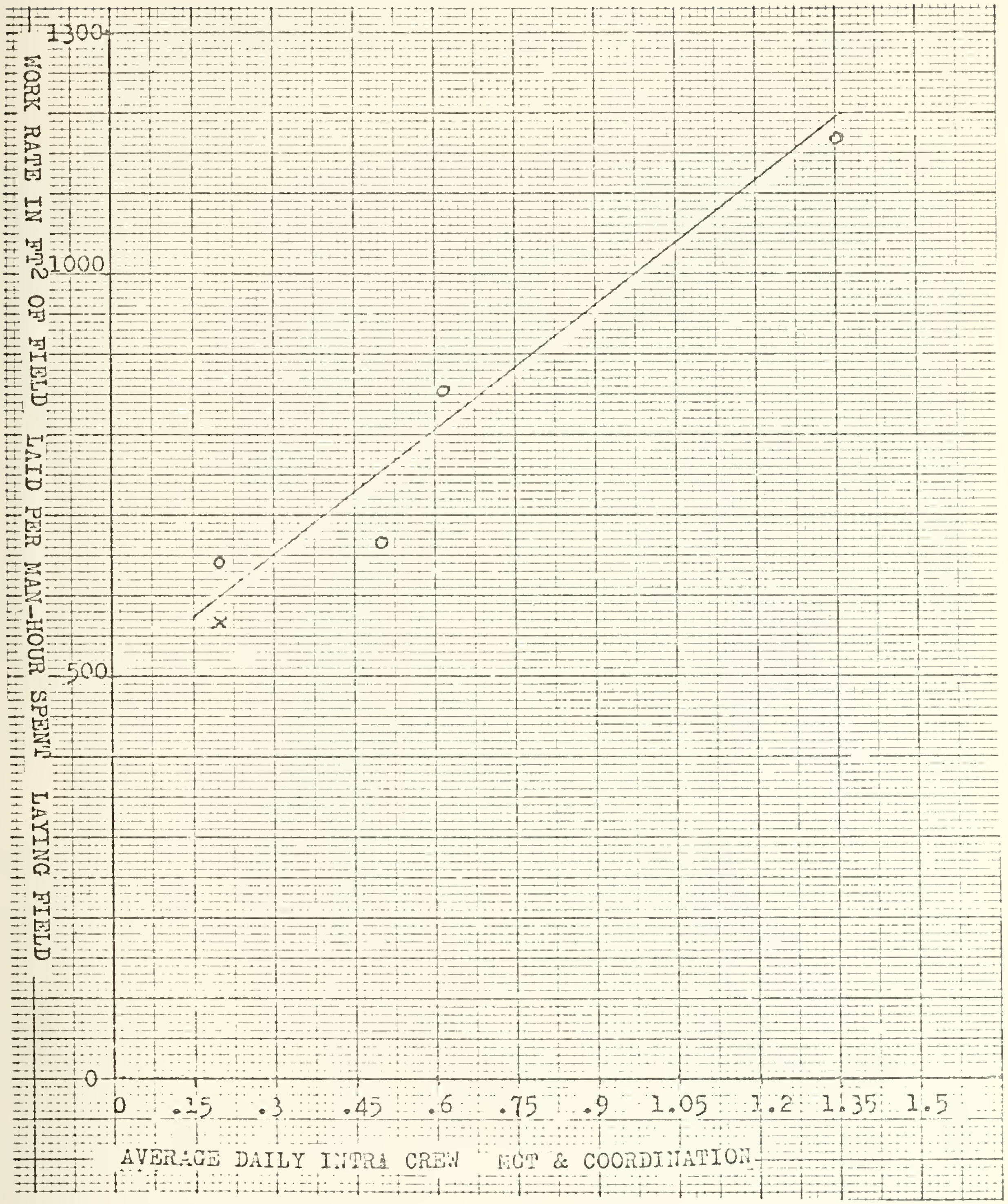
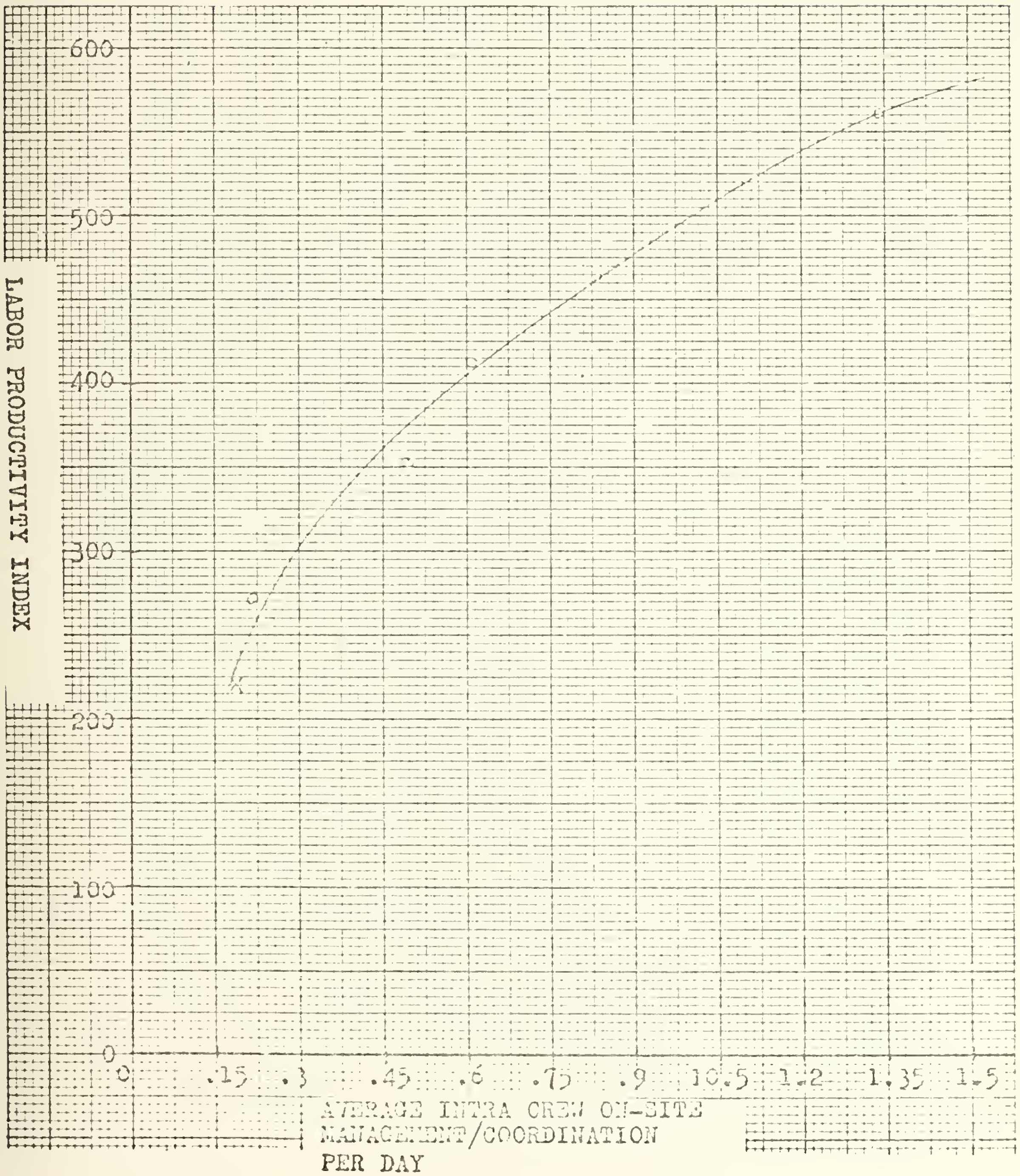


FIGURE 4-12

LABOR PRODUCTIVITY INDEX VERSUS AVERAGE INTRA-CREW ON-SITE MANAGEMENT



4) The amount of average daily intra-crew management and coordination was correlated directly with the average time the field supervisor spent daily in contact with the crew through on-site inspections and contact with the leadman on the phone.

5) Figure 4-13 indicated that the average number of man hours spent in on-site management and coordination per day was directly related to the average number of man hours per day that the field supervisor spent in contact with the crew.

6) Figure 4-14 indicated a correlation between the percent of total on-site man hours delayed by home-office causes and the percent of total on-site man hours spent in productive work.

7) There was a correlation between work rate and the total on-site delays (Figure 4-15).

8) There was a correlation between work rate and the percentage of total time on breaks although weak (Figure 4-16).

9) There was a general correlation between the work rate and the percentage of on-site time spent in productive work (Figure 4-17).

10) There was a general correlation between the percentage of total man hours spent in productive work and the percentage of total on-site man hours spent on breaks or non-job related situations (Figure 4-18).

11) A comparison of Job #3 and Job #4 was identical in area to perimeter ratio, percent of time spent in breaks, percent of time lost to delays, training of personnel, experience of personnel, and job conditions. A 76 percent increase in work rate and a 59 percent increase in the labor productivity index occurred.

AVERAGE INTRA-CREW ON-SITE MANAGEMENT VERSUS AVERAGE TIME SUPERVISION IN CONTACT WITH CREW

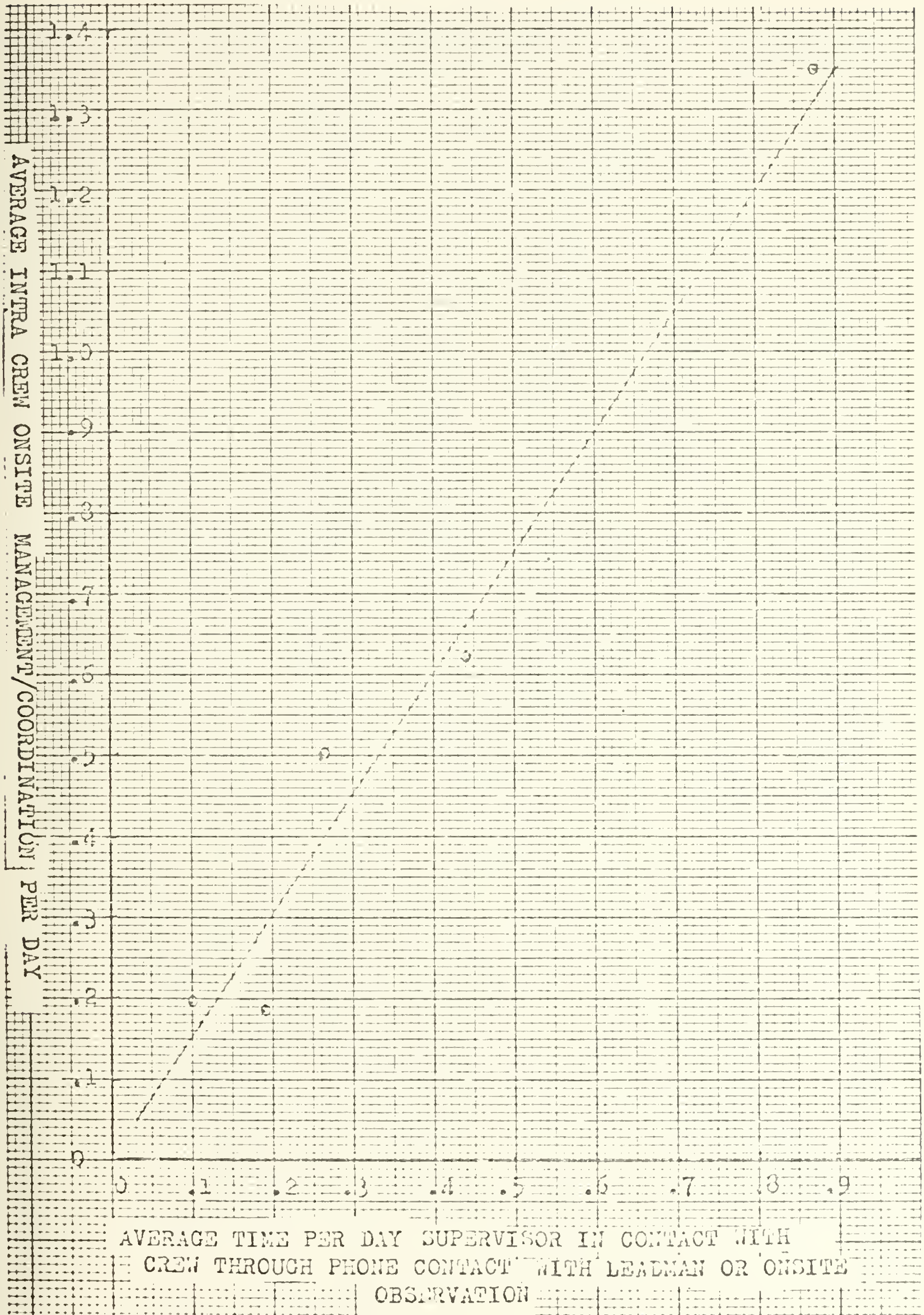


FIGURE -4-13

PERCENT OF TOTAL TIME DELAYED BY HOME-OFFICE DELAYS VERSUS PERCENT OF TOTAL ON-SITE TIME SPENT IN PRODUCTIVE WORK

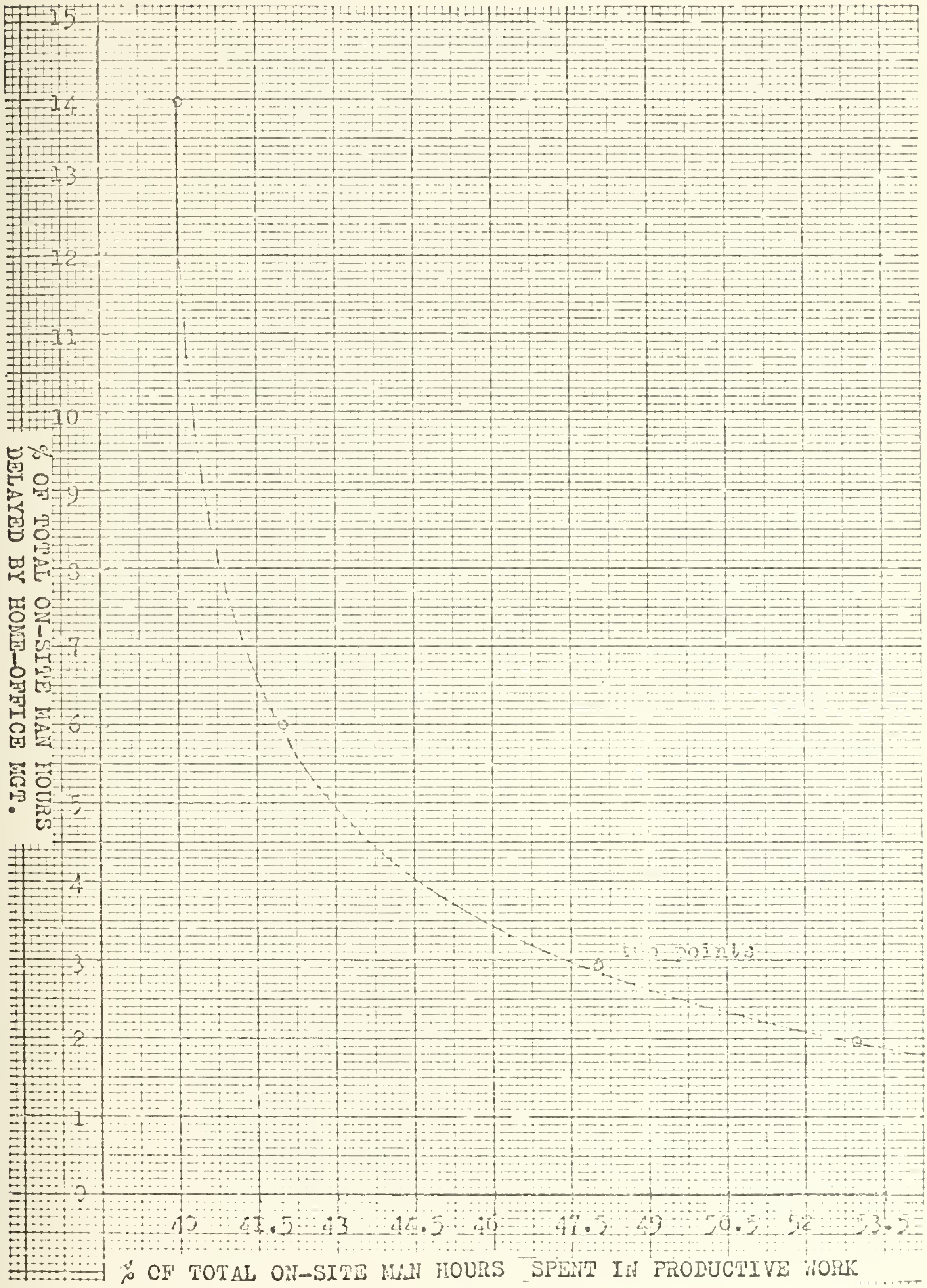


FIGURE 4-14

FIGURE 4-15

WORK RATE VERSUS PERCENT OF TOTAL ON-SITE TIME DELAYED FOR ANY REASON

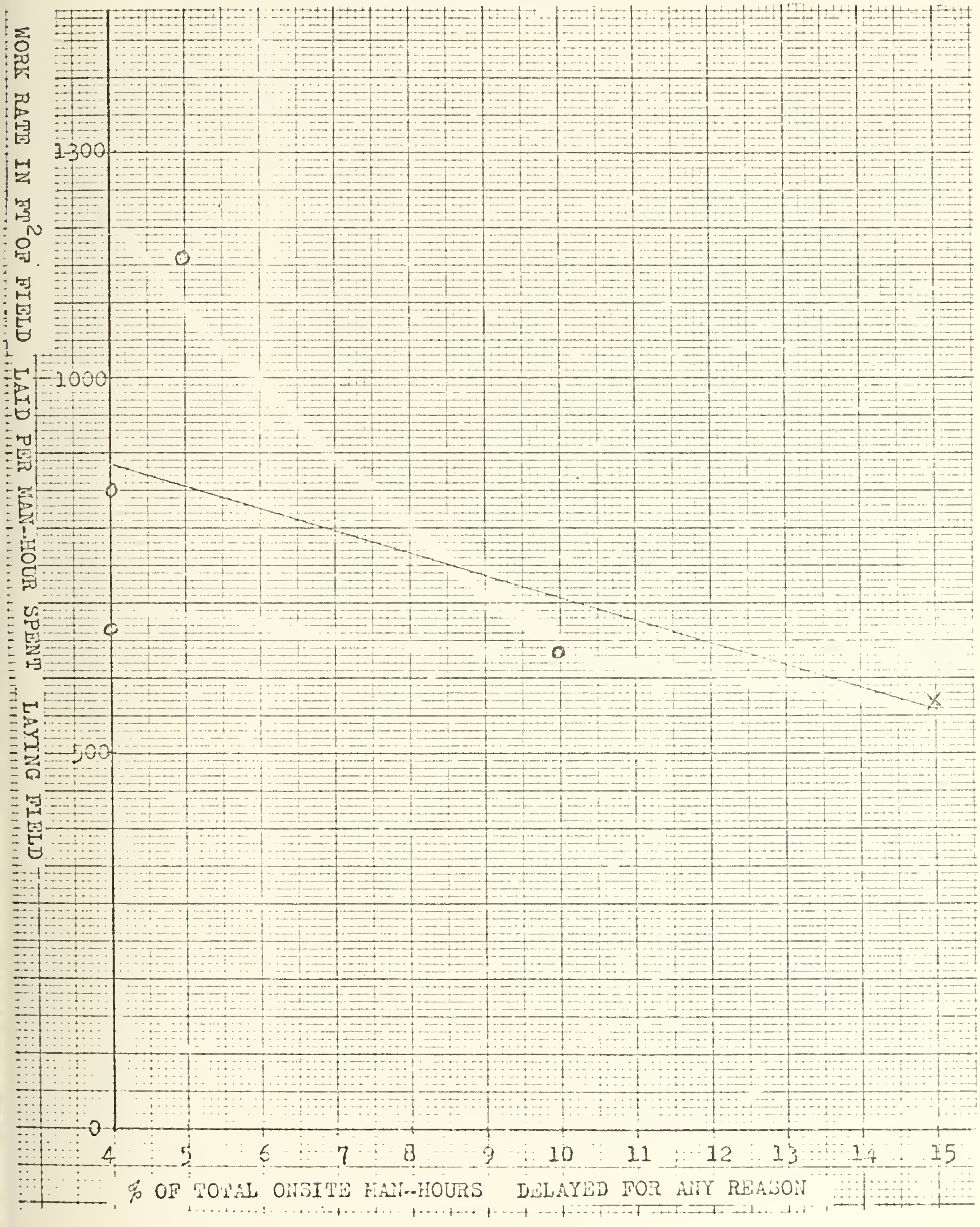


FIGURE 4-16

WORK RATE VERSUS PERCENT OF TOTAL ON-SITE TIME
SPENT ON BREAKS OR NON-JOB RELATED ACTIVITIES

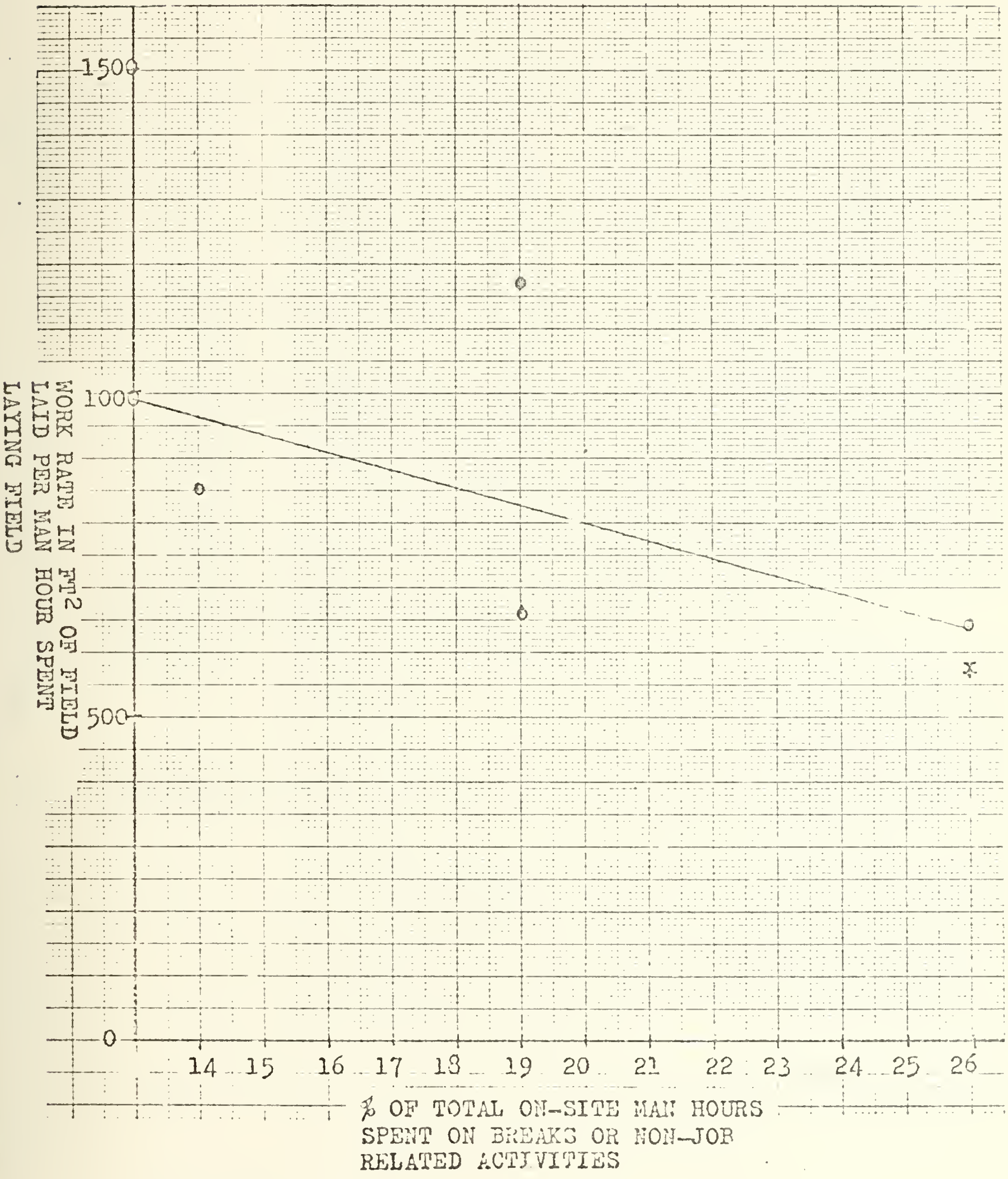


FIGURE 4-17

WORK RATE VERSUS PERCENT OF TOTAL ON-SITE
TIME SPENT IN PRODUCTIVE WORK

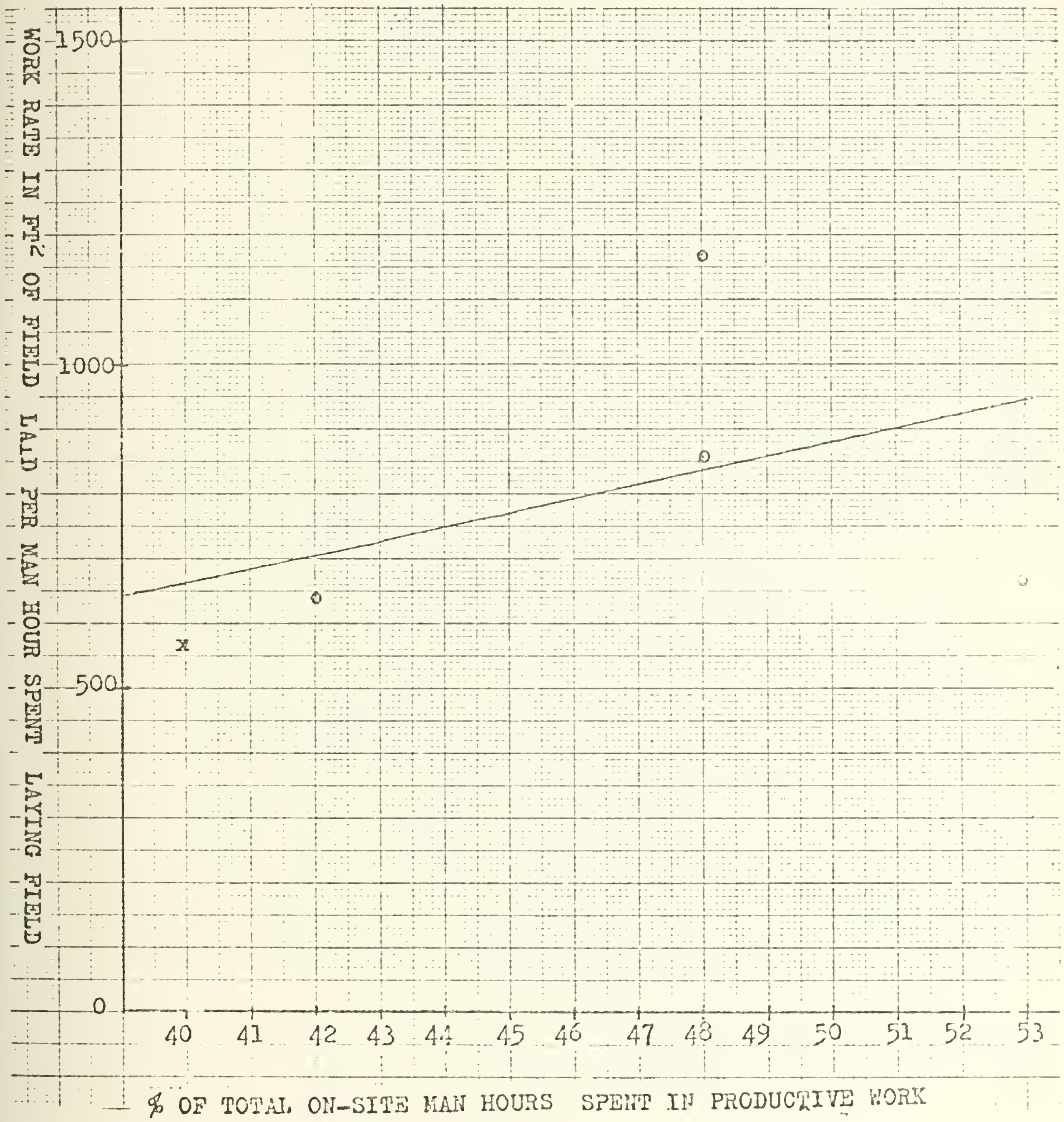
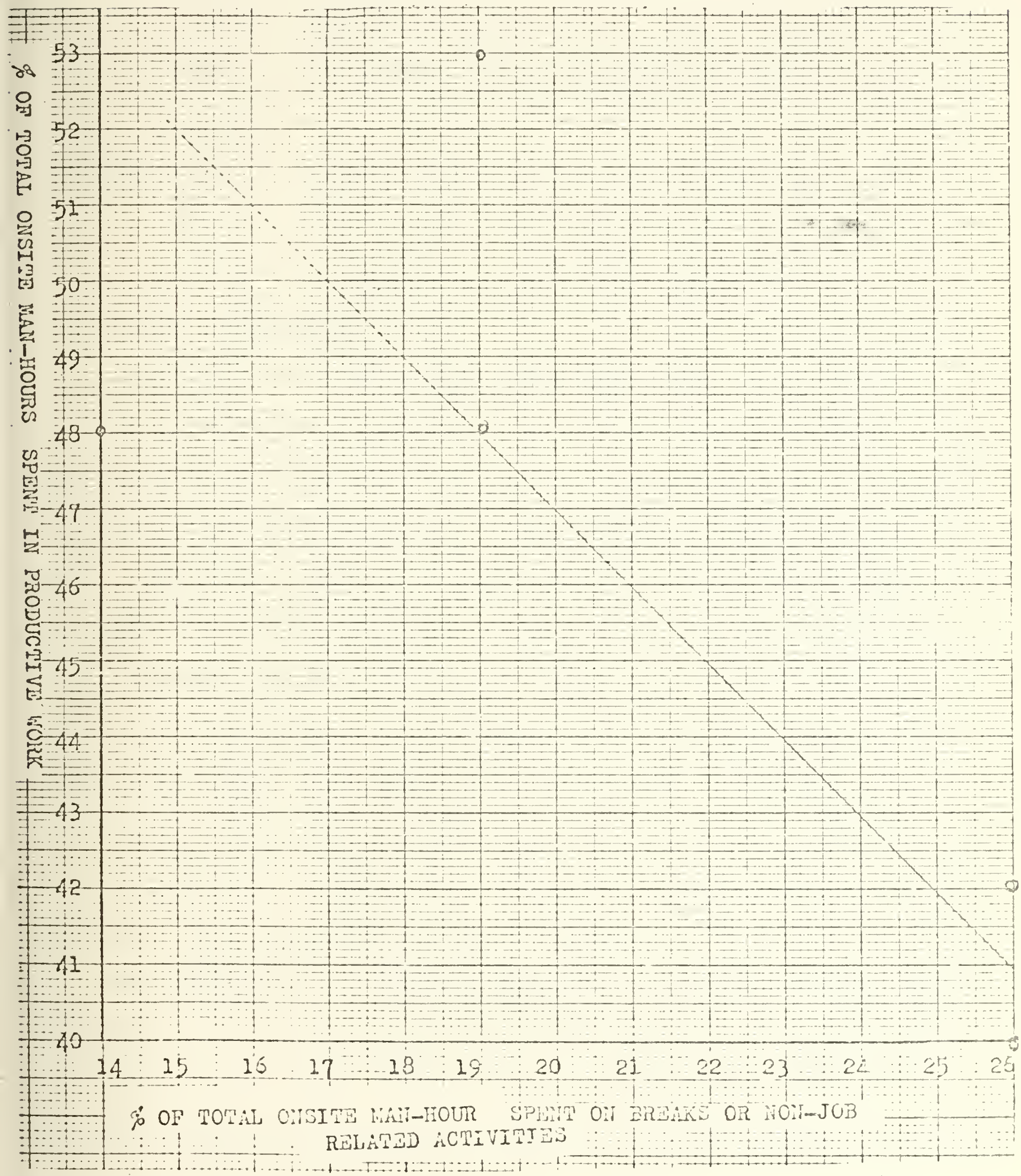


FIGURE 4-18

PERCENT OF TOTAL ON-SITE TIME SPENT IN PRODUCTIVE WORK VERSUS PERCENT OF TOTAL ON-SITE TIME SPENT ON BREAKS OR NON-JOB RELATED ACTIVITIES



12) A comparison of Job #1 to Job #5 showed that both jobs had similar area to perimeter ratios, percentage of time being productive, extent of on-site supervision, quality standards, training of crew members, and supervisor motivation. And, yet, there was a 75 percent increase in work rate in Job #5 over Job #1.

13) Extensive comments by the workers and observations by the observer on the managerial practices, motivational factors, and technical problems were collected (Appendix E).

4.5.5 Conclusions

The Phase three strategy and methodology proved very successful. By being on the job site continuously work rates could accurately be determined. The time spent on each activity was recorded and the comments of workers themselves were noted. This permitted correlation between verbal comments and observed performance as well as clarification of motivation and management. Vinyl asbestos tile laying was especially suited for an analysis of productivity parameters since the basic work activities were simple and few in number. This simplicity permitted the comparison of labor productivity except where there were variations in the method of installation, the tools used, and the building materials. However, these three items were all basically constant for Union trained workers in shops specializing in floor finishing.

The methodology also permitted expanding the study to other areas of labor productivity beyond the impact of management. The personal contact with workers allowed the collection of information on worker's heritage, education, interests, and aptitudes. These traits could be

related to work rates as well. The range of possibilities for productivity studies using this methodology was limited only by the complexity of the trade being reviewed.

General labor productivity trends in vinyl asbestos tiling were hinged on the notable fact that large differences in work rate occur in identical activities of similar jobs. This fact lead to the following conclusions:

1) The results indicated that the amount of on-site intra-crew management and coordination was related to the work rate and labor productivity. The initial man hours of this form of management had a greater utility for improving overall labor productivity than do later ones. This was reasonable since the addition of too much management resulted in people spending too much time managing and not enough time working. This was the classic case of too many chiefs and not enough indians.

2) The results indicated that where home-office management-delays were noticed on-site, there was a strong possibility of other managment problems existing. In a sense, the observation of home-office management-delays was only the tip of the iceberg and should be a warning of other problems. Significantly, there was also a strong correlation between the amount of home-office contact with the work crew and the work crew's work rate. Putting these two facts together indicated that good management made the productivity even better and poor management made it even worse.

3) The results supported the contention that the presence of delays as an indicator of interference affected work rate adversely.

4) Although less significant, the results supported the contention that the amount of time on breaks adversely affected the work rate. It would appear that the crews that took extremely long breaks suffered from a break in their momentum.

5) The results generally supported the concept that overall labor productivity was related to observed time spent in productive work.

6) A comparison of similar jobs (Job #3 and Job #4) provided additional insight into the motivational and managerial inputs of high labor productivity. On the "faster" job there was a larger work force allowing greater specialization of function. In addition, the comments of workers indicated intense competition for work, allowing management to set high expectations on the work rate. Although the motivation to achieve a steady income through continuous work with one shop was present in both jobs, an interesting phenomena may have established the much higher "quota" in the "faster" shop. Apparently, in previous years the field supervisor had been given bonuses for having the fastest crews in the shop. There was no comment as to whether the field supervisor allowed this monetary reward to be filtered down. However, opportunities existed to pass on gain in other ways. Over the years the "faster" shop had raised its quota commensurate with the fastest crew. The shop was successful and therefore was able to offer continuous work for employees as an incentive for staying with the shop and meeting the shop quotas. At the present, the shop has no formal practice of monetary reward. However, the accountability for

maintaining the work rate remains, and the workers who have stayed with the shop have become conditioned to the pace and do not mind working at it. They are willing to continue working at the same rate, and state that the conditioning is the central element in their speed.

7) A comparison of similar jobs (Job #1 to Job #5) also provided information on management parameters affecting labor productivity. The major differences between these jobs was job security and work experience. Together these two factors accounted for a 75 percent improvement in labor work rate. Using the assumption adopted earlier, the fact that one of these crews had not worked continuously as trained tile layers but as carpenters, affected 56 percent of the increase. The other 19 percent would be accounted for by the lack of job seniority or job security.

In summary, management affected labor productivity in even the simplest building skills such as vinyl asbestos tile laying. Although job conditions affected the work rate, management's short and long term strategy greatly affected the speed of a job. Although implementation of a strategy could have increased management costs, the savings may have come from shortened construction time. The long term strategy was oriented to retaining good workers without the use of seniority. Where this could be done, the shop as a whole would be conditioned to work at competitive rates so that they could depend on steady work. In the short term strategy, on-site management and coordination of the work through a field supervisor was significant. Home-office interest in the work rate and the motivation of individual workers re-enforced and established

informal quotas. Productivity improvement was a result of long and short term strategy.

CHAPTER FIVE

PRODUCTIVITY ANALYSIS PROCESS AND CASE STUDY CONCLUSIONS

5.1 INTRODUCTION

As shown in Figure 1-1 the analysis methodology and the case study were developed concurrently. Improvements in the case study aided the methodology and vice versa. As a result of the case study, the methodology for measuring management's effect on construction labor productivity seems apparent and is presented here. Certain advantages of current labor efficiency studies are applicable to this procedure and are noted at the end of chapter two. The objective of the proposed methodology is to assist in developing strategies for determining, analyzing and subsequently improving labor productivity.

5.2 ASSUMPTIONS

Three basic assumptions are made to assist in meeting this objective. The first is that a standard identifiable activity within a building operation can be found that has a work rate representative of the entire operation. The work rate of an activity is defined in this paper as the amount of work accomplished for a given amount of time actually spent in performing the activity. For example, if 1000 sq. feet of tile are laid in a field of tile in one man hour, then the work rate is the ratio of 1000 sq. feet of tile to one man hour when the entire time is spent laying the tile in the field. Other activities related to laying tiles such as transporting tiles to the work area, preparing tools, and smearing adhesive on the subsurface are excluded from this man hour of labor input. Movements directly involved in tile laying, however, are considered part of the labor input (e.g. reaching for another tile, moving forward to

install the next tile). Not all activities of an operation will have a measurable work rate. The model activity, however, is chosen as a consistent activity to represent the entire operation. As such, it must be one that is performed in a uniform manner on all jobs. Not only is it important to determine that the model activity represents the building operation, but also to establish an exact delineation of what constitutes the model activity.

The second assumption is that the model activity is capable of being isolated in time and space -- not dependent on physical characteristics of the job site. Both the labor time expended in performing it and the output of that labor must be quantifiable to an observer of the work. As in assumption one, this requires careful selection and an exact definition of the model activity. The activity must be performed so that labor input can be clearly seen and quantified. Work in hidden ducts, for example, would not be appropriate as a model activity.

The third assumption is that a determination can be made as to how much of the total on-site labor time is spent in productive work. This assumption requires careful definition of what constitutes productive work. It is also dependent on the ability of the observer to categorize whether work is productive or not.

From these three assumptions, an index representing the total labor productivity on a particular job is defined. This productivity index equals the model activity work rate (assumption one and two) times the percentage of total time on-site spent in productive work (assumption three).

The scrutiny required in selecting an appropriate model activity may limit this methodology to simple operations. Where this is the case, complex building operations may have to be modeled in simpler trades (e.g. tile laying). Although such modeling might not provide accurate information on the effect of management on labor in specific trades, it would indicate the order of magnitude of management actions.

5.3 METHODOLOGY FOR DATA COLLECTION

Figure 5-1 indicates the sequence of data collection. This sequence is as follows. The building operation in question is studied and a model activity is determined. This is accomplished by identifying all component activities of the operation, and selecting the ones that fit assumptions one and two. If several are identified to meet this requirement, then the one most easily observed that interferes the least with the work, is selected. Where an appropriate model activity cannot be found, selection of a building operation with similar management parameters is sought that does have an appropriate model activity. Measures of labor input and work output that are numerically quantifiable are identified for the model activity. Paralleling this process is the identification and refinement of the major management parameters of this operation. Professional experience may be needed in identifying these parameters. Quantifiable measures of management parameters are identified (e.g. number of hours on-site supervision).

Prior to collecting data, a detailed data collection procedure specific to the jobs being observed, is determined. The following items should be included in this procedure: definition of productive work, preparation of necessary data collection forms, identification of potential observation problems, and arrangements for job observation times with

METHODOLOGY FOR COLLECTING DATA

IDENTIFY BUILDING OPERATION OF INTEREST

RESEARCH OPERATION
1. basic materials, labor, equip
2. interface with other trades
3. standard means & methods in construction
4. special problems in operation

IDENTIFY NON-TECHNICAL MANAGEMENT PARAMETERS FOR OPERATION
1. crew selection
2. motivation, crew & individual
3. supervision, each level onsite
4. quality of work required
5. coordination requirements

DETERMINE MODEL ACTIVITY
1. standard means & methods
2. significant subset
3. a keying activity

IF CAN'T DETERMINE SUITABLE MODEL, SELECT BUILDING OPERATION WITH SIMILIAR MGT PARAMETERS/ RETURN ABOVE

REDUCE TO SIGNIFICANT PARAMETERS
1. to accomodate purpose & resources
2. knowledge of trade

IDENTIFY INPUT &OUTPUT MEASURES OF WORK RATE
1. numerically quantifiable
2. easily identifiable

IDENTIFY MEASURES OF PARAMETERS
1. numerically quantifiable
2. easily identifiable

SELECT DATA COLLECTION TECHNIQUE
1. can measure level of work rate
2. can measure level of mgt parameters
3. minimizes observer interference in work
4. accomodates to purposes & resources
5. establish mutually exclusive collectively exhaustive catagories for work activity during observation

DATA COLLECTION PROCEDURE
1. all operations similiar in means, methods, and materials
2. model activity is similiar
3. continuous observation of operation for 3-5 days depending on nature of operation
4. significant number of observations, six times as many observations as significant parameters

FIGURE 5-1

contractors. The collection procedure also includes the identification of how, when, and where the observer will locate himself on the job site to collect the information. Safe-guards to minimize distracting influences of the observer on the work force are evaluated and included in the procedure.

Once the technique for data collection is established, and all observers are acquainted with the procedure, on-site observation of actual jobs can begin. While actually on the job site, care must be taken to follow the standard observation procedure, to note all job conditions and to accurately record worker comments. From the experience in the case study, three to five days appears to be an appropriate length of observation for vinyl asbestos floor tile. This allows the observer to watch the work flow long enough to determine the level of management action present on the job, establish himself to the workers as not being part of management, and determine any unusual circumstances peculiar to the job being observed. Five days appears to be the more preferred observation period as it affords more time for the informal information gathering.

The number of jobs that should be observed is dependent on the number of management actions being evaluated, the degree of confidence sought, and the resources available. If more parameters are being analyzed than the number of jobs observed, the results of the study may not be conclusive.

5.4 METHODOLOGY FOR ANALYSIS OF DATA

The analysis process is indicated on Figure 5-2. The process works to the determination of the two measures of labor productivity -- model work rate and percentage of total on-site time spent in productive work -- and the derived productivity index. This is accomplished in the following

METHODOLOGY FOR ANALYSIS OF DATA

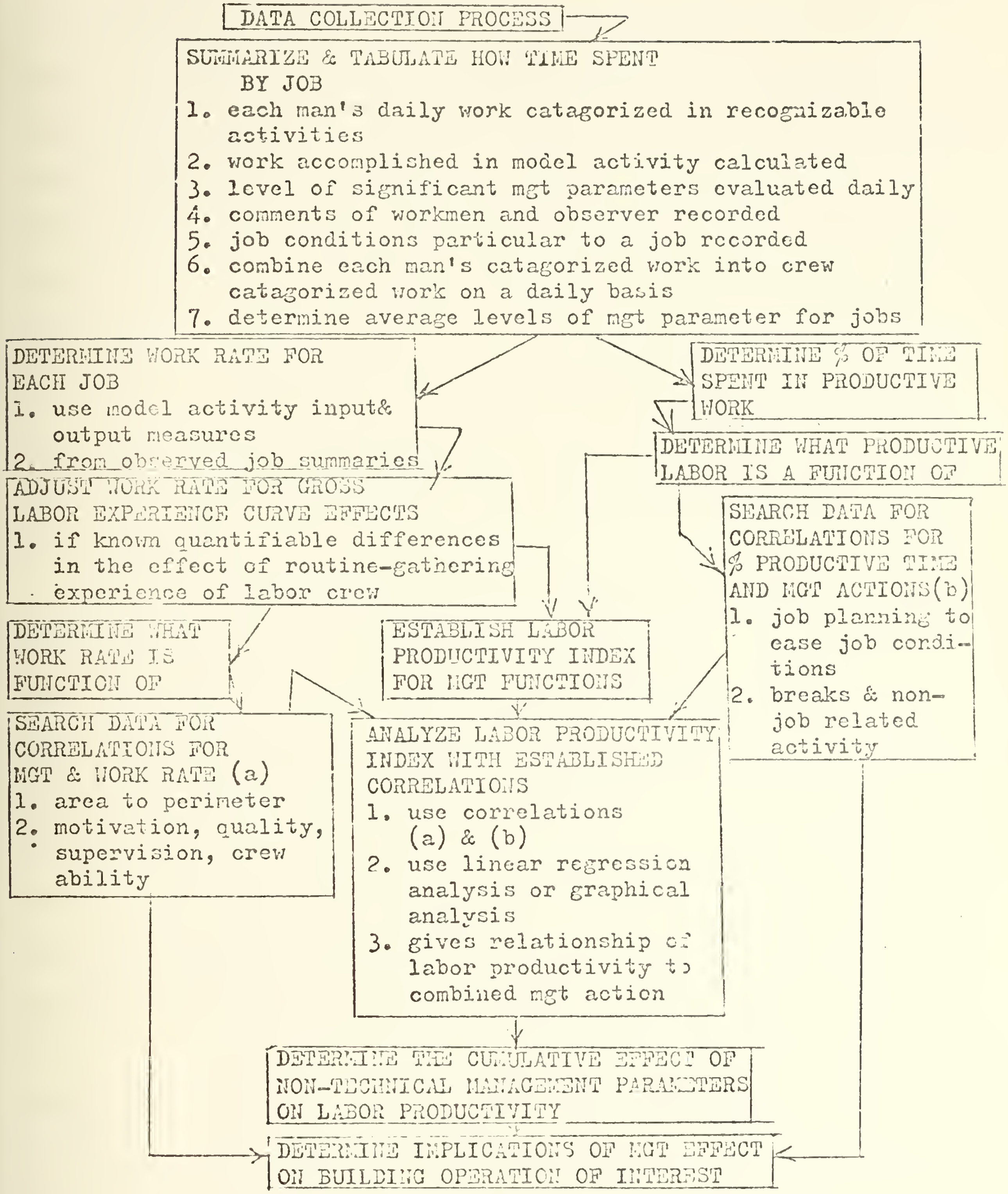


FIGURE 5-2

manner. From the observer's daily progress log each man's individual daily activities are identified and organized into a time stream of standard activities. The summation of time spent in each standard activity each day per man is then determined. The work accomplished daily in the model activity is also noted daily. At the end of the observation period a model activity work rate for the entire period is calculated from the work accomplished per total man hours spent in performing the work. The work rate is adjusted for gross labor experience curve effects, if known. By multiplying this adjusted work rate times the observed percentage of time spent in productive work, the productivity index for the job is determined.

At this point, a complete review of the observer's comments as well as those of the workmen, are made to identify management actions that might have dominated the job. These management actions along with the formally assessed management parameters are compared to the productivity indices. By graphing the productivity index against the quantifiable management actions and parameters for all jobs, trends can be observed. The work rate and percentage of time spent in productive work can also be graphically compared to management actions and parameters. Although such an analysis provides no additional information about the effect of management actions on labor productivity, it does indicate the mechanisms by which productivity is changed. From data points that appear to be indicative of a straight line correlation, a least-square-best-fit line is constructed. Where the points appear to fall on a curve, such a curve is drawn. Logarithmic and semi-logarithmic graph paper is also used to establish correlations between management actions and labor productivity. By analyzing these graphical presentations, the cumulative effect of management

actions can be broken into assessments of individual management actions on labor productivity. An alternative to the graphical analysis may exist where there are significantly more jobs observed than there are management actions being assessed. Under these circumstances, a linear regression analysis of the level of management actions to the productivity index may be possible.

5.5 CASE STUDY CONCLUSIONS

This methodology was applied to the study of vinyl asbestos floor tiling as indicated in phase three of the case study. The following points are supported by the conclusions in the case study:

1) Measurement and analysis of labor productivity in vinyl asbestos floor tiling showed that large differences in work rate and labor productivity were possible on similar jobs.

2) There was a correlation between the work rate and the area to perimeter ratio. The more open areas allowed more freedom of movement, and generally were associated with a larger number of repetitions of an identical task.

3) The average time per day that the supervisor (the leadman's home-office contact) spent in contact with the crew, directly related to the amount of average intra crew on-site management and coordination per day.

4) The average time spent in intra crew on-site management and coordination per day was correlated closely with the labor productivity index and the work rate. This indicated a link between the presence of on-site management coordination among crew members and an increase in labor productivity. Although this was not at all a startling discovery, it was interesting in light of the fact that the amount of time the crew

spent on on-site management of the work was directly correlated to the amount of time the home-office supervisor spent with the crew. Although insufficient confidence resulted from this small sample, an average of one hour per day of the supervisor's time spent with the crew appeared to yield an average of one and a half man-hours of on-site management coordination per day.

5) The percent of on-site man-hours spent in productive work was correlated to both the labor productivity and the work rate. This would support the theory that work sampling is a reasonably accurate method of determining labor productivity.

6) There was a general correlation between the work rate and the percent of time delayed for any reason. This would support other findings that interruptions tend to demoralize the workmen and slow down the work pace.

7) There was a weak correlation between the percent of total time spent on breaks or non-job related activities and the work rate. This would support the idea that excessive breaks tend to destroy the momentum of the work.

8) The use of the telephone as a way for the supervisor to keep in touch with the work crew appeared to be an effective complement if not a replacement for daily on-site inspections.

9) Motivators in the form of money or reputation for home-office supervisors responsible for field work could make a significant difference in labor crew work rates.

10) There was a correlation between a decrease in the percent of total on-site time spent in productive work and the percent of total time delayed by home-office management problems. This implied that the effect

of poor planning as indicated by management caused delays was only the tip of the iceberg. Where poor planning had resulted in definite delays accountable to the home-office, other areas of planning had probably been neglected.

11) Comments of the workmen themselves indicated that the work rate and labor productivity was driven primarily by job security and long term pacing. It was necessary to meet management's expectation of work pace in order to be rehired and therefore guaranteed a steady income since tile layers do not accumulate job seniority.

12) The cumulative effect of the following management actions improved labor productivity one hundred percent or greater: extensive on-site management and coordination, an economic link between job security and production, long term pacing.

Because of the small number of jobs observed, these conclusions must be considered indicative rather than predictive. The author suggests further research to develop data for a predictive model. Such a model can provide managers in the construction industry with concrete indications of what productivity they might reasonably expect, strategies for achieving their expectations, and mechanisms for assessing their own effectiveness.

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APPENDIX A

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APPENDIX B-1

SCENARIO INTERVIEW FORM 1

Date

Source

General Method of Installation:

Tools Required:

Materials and Quantity, Description:

Curing Time and Installation Problems:

Estimated Job Rate:

Other:

APPENDIX B-2 SCENARIO INTERVIEW FORM

LEVEL OF SUPERVISION: GENERAL GUIDANCE ONLY ____ MAN HRS

		OPTIMUM CREW (COLUMN 1)	ADD 1 TO OPTIMUM CREW: JOURNEY-MAN	ADD 1 TO OPTIMUM CREW: APPREN-TICE	ADD 1 TO OPTIMUM CREW: HELPER	SUB 1 FROM OPTIMUM CREW: JOURNEY-MAN	SUB 1 FROM OPTIMUM CREW: APPREN-TICE	SUB 1 FROM OPTIMUM CREW: HELPER
TOOLS & EQUIPMENT SET #1	JOURNEY-MAN							
	APPRENTICE (1-4 YRS EXP)							
	HELPERS (<1 YR EXP)							
	TIME TO COMPLETE							
	% TIME THAT CREW MEETS SPECS							
TOOLS & EQUIPMENT SET #2	JOURNEY-MAN							
	APPRENTICE (1-4 YRS EXP)							
	HELPERS (<1 YR EXP)							
	TIME TO COMPLETE							
	% TIME THAT CREW MEETS SPECS							
TOOLS & EQUIPMENT SET #3	JOURNEYMAN							
	APPRENTICE (1-4 YRS EXP)							
	HELPERS (<1 YR EXP)							
	TIME TO COMPLETE							
	% TIME THAT CREW MEETS SPECS							

LEVEL OF SUPERVISION: INITIAL ONSITE GUIDANCE PLUS REVIEW @ COMPLETE ____ MAN HRS.

		OPTIMUM CREW	ADD 1 TO OPTIMUM CREW: JOURNEY-MAN	ADD 1 TO OPTIMUM CREW: APPREN-TICE	ADD 1 TO OPTIMUM CREW: HELPER	SUB 1 FROM OPTIMUM CREW: JOURNEY-MAN	SUB 1 FROM OPTIMUM CREW: APPREN-TICE	SUB 1 FROM OPTIMUM CREW: HELPER
TOOLS & EQUIPMENT SET #1	JOURNEY-MAN							
	APPRENTICE (1-4 YRS EXP)							
	HELPERS (<1 YR EXP)							
	TIME TO COMPLETE							
	% TIME THAT CREW MEETS SPECS							
TOOLS & EQUIPMENT SET #2	JOURNEY-MAN							
	APPRENTICE (1-4 YRS EXP)							
	HELPERS (<1 YR EXP)							
	TIME TO COMPLETE							
	% TIME THAT CREW MEETS SPECS							
TOOLS & EQUIPMENT SET #3	JOURNEYMAN							
	APPRENTICE (1-4 YRS EXP)							
	HELPERS (<1 YR EXP)							
	TIME TO COMPLETE							
	% TIME THAT CREW MEETS SPECS							

LEVEL OF SUPERVISION: SAME AS BEFORE PLUS RANDOM INSPECTIONS ____ MANHRS.

		OPTIMUM CREW	ADD 1 TO OPTIMUM CREW: JOURNEY-MAN	ADD 1 TO OPTIMUM CREW: APPREN-TICE	ADD 1 TO OPTIMUM CREW: HELPER	SUB 1 FROM OPTIMUM CREW: JOURNEY-MAN	SUB 1 FROM OPTIMUM CREW: APPREN-TICE	SUB 1 FROM OPTIMUM CREW: HELPER
TOOLS & EQUIPMENT SET #1	JOURNEY-MAN							
	APPRENTICE (1-4 YRS EXP)							
	HELPERS (<1 YR EXP)							
	TIME TO COMPLETE							
	% TIME THAT CREW MEETS SPECS							
TOOLS & EQUIPMENT SET #2	JOURNEY-MAN							
	APPRENTICE (1-4 YRS EXP)							
	HELPERS (<1 YR EXP)							
	TIME TO COMPLETE							
	% TIME THAT CREW MEETS SPECS							
TOOLS & EQUIPMENT SET #3	JOURNEYMAN							
	APPRENTICE (1-4 YRS EXP)							
	HELPERS (<1 YR EXP)							
	TIME TO COMPLETE							
	% TIME THAT CREW MEETS SPECS							

PRIMARY MATERIAL STUDIED ____________ INTERVIEWEE ____________

THIS INFORMATION IS FOR SPECIFIC SCENARIO PRESENTED DATE ________

APPENDIX B-3 SUMMARY OF METHODS CONSIDERED

PRIMARY MATERIAL	METHOD INSTALL	APPROX INSTALL (FOR APTS.)	APPROX CURE TIME	COMMENTS
LINOLEUM	SHEET	50 YD^2/MAN DAY 400 FT/MAN DAY (FOR BASE)	24 HOURS	REQUIRES MORE SKILL THAN TILING IN LAYING
ASPHALT	TILE	750 FT^2/MAN DAY (FOR FIELD) 400 FT/MAN DAY (FOR BASE)	48 HOURS	POTENTIAL PRODUCTIVITY IMPROVE BY GOOD MANAGEMENT IF BREAK INTO FIELD, SMEAR, AND FITTING*
VINYL-ASBESTOS	TILE			
FLEXIBLE VINYL	TILE	600 FT^2/MAN DAY 400 FT/MAN DAY	24 HOURS	
QUARRY TILES	ORGANIC ADHESIVE	2 MEN CAN DO 125 FT^2/ DAY	72 HOURS AFTER GROUTING	MAY NOT HOLD UP IN HUMID CLIMATE
	THIN SET DRY SET	2 MEN CAN DO 125 FT^2/DAY		USE PRESIXED MORTAR
	CONVENTION-AL MORTAR	2 MEN CAN DO 100 FT^2/ DAY		HAS UNDERBED; GOOD FOR PRECAST SUBFLOOR OR SUBJECT TO BENDING
	EPOXY THIN SET	2 MEN CAN DO 125 FT^2/ DAY	40 HOURS AFTER GROUT	WAIT 16 HOURS AFTER TILE SETS TO GROUT; SHADE FROM SUN 8 HOURS AFTER GROUTING
TERRAZZO(IN SITU)	SAND CUSHION	NO TIMES GIVEN; EACH SURFACE TREATED IN 4 STAGES: UNDERBED, TERRAZZO TOP, GROUT, SEALER	UNDERBED- 1 DAY; TOP- 2-5 DAYS; GROUTING- 1-2 DAYS	USED WITH PRECAST CONCRETE
	BONDED MONOLITHIC			
	THIN SET EPOXY			

*CAN SMEAR 5000 FT^2/MAN DAY; INSTALL FIELD @ 1500 FT^2/MAN DAY; CAN FIT EDGE EQUIVALENT TO AREA OF 2000 FT^2/MAN DAY.

APPENDIX C-1

LETTER OF INTRODUCTION

DEPARTMENT OF CIVIL ENGINEERING
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASSACHUSETTS 02139
Room 1-253

October 26, 1976

Dear Sir:

Massachusetts Institute of Technology is currently conducting a research study aimed at evaluating the potential for productivity improvement in the construction of multi-family housing in a developing country. In order for us to be able to project potential productivity improvement, and determine what is necessary to achieve such projections, we must determine current productivity in the U.S. and how a variety of factors affect it. We are currently surveying operations on floor finishing. We have prepared a survey and would like to arrange to execute this survey on one or two of your current projects involving floor finishing.

We have devised a survey instrument which we would complete by interviewing your supervisory staff and workers. A copy is enclosed for you review. We expect to be able to identify and quantify various factors effecting productivity with this survey. We recognize the difficulty in quantifying some of the factors, but feel we must in order to develop the capability to project our data with foreign conditions to a different culture.

Conduct of the survey requires a brief interview at the site and in your home office at the completion of a flooring job. The survey will be administered by an M.I.T. graduate student in the Department of Civil Engineering. Survey results will be held in strictest confidence.

We will be contacting you shortly, after you have had a chance to review the survey instrument, to answer any questions you may have about our operating procedures and use of our data. We would like to obtain your agreement to survey some of your work and employees, and to make necessary arrangements to do so.

Let me point out that, even in this country, productivity improvement is thought to be the single most important research task for the construction industry. Your cooperation will help here, as well as for the target country, where productivity is two to three times poorer.

Thank you very much for your cooperation and assistance.

Sincerely yours,

Robert D. Logcher
Professor of Civil Engineering

APPENDIX C-2

SAMPLE OF SURVEY INSTRUMENT

DEPARTMENT OF CIVIL ENGINEERING
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASSACHUSETTS 02139

Productivity Improvement Survey

Please fill out a separate questionaire for each job. If any of the information requested is unavailable or confidential, write "NA" or "Conf" after the question. The supervisor, for the questionaire, is defined as the subcontractor's representative to whom the lead man on the job is responsible.

1. Job Description:
a. Location of job site:

b. Briefly describe the job (e.g. a corridor of a school):

c. Dates work started and ended:

d. Number of days actually worked:

e. Number of hours worked per day:

f. Number of FT^2 of floor area for job:

g. Number of FT of perimeter including footage around any intrusions:

2. Flooring Material, Equipment, and Method (ask supervisor in home office):
a. Flooring material used including base

Description of item	Quantity

b. Tools & equipment supplied by contractor used for onsite installation for entire crew

Description of item	Quantity	Cost (if owned, initial cost & useful life; if rented, rate & period of rental)

c. General method of laying flooring(e.g. equalize, smear, dry four hours, install field, install edge, install base):

3. Crew Make-up and Interaction (RECORD ANSWERS ON NEXT PAGE)

a. On the following sheet each man's response is recorded in part (a).

b. The supervisor fills in each man's name (or ensures each man is on the list) who was involved in the job. In addition, the supervisor fills in part (b) for the individual crew members.

PERSONNEL NAMES INCLUDE LEADMAN / QUESTIONS								
Part (a)								
Skill rating(e.g. appr, journeymen)?								
Months experience laying of this method?								
Months of formal craft training?								
Does person's performance affect any of following: Getting a bonus?								
Does person's performance affect any of following: Work on other jobs?								
Does person's performance affect any of following: Promotion in the company?								
Has person worked with any of the others before this job?								
Has person worked for the lead man before this job?								
Is this person union or non-union?								
What tools are you using of you own? (List on back if not enough room)								
Part (b)								
No. of hours straight time on job?								
No. of hours overtime on the job?								
Of total straight and overtime, how many hrs. spent on rework?								
Straight pay per hour including benefits?								
Overtime pay per hour including benefits?								

3. Questions for the lead man on the job.(CIRCLE THE CORRECT ANSWER)

a. Is there any field supervision over you? YES/NO

b. How often did the supervisor come on the job site? DAILY, EVERY OTHER DAY, EVERY THIRD DAY, LESS OFTEN

c. What % of the entire job was the supervisor on the job site? ______

d. Were the visits announced? YES/NO

e. Were there any delays in the progress of work? (if YES,what?) YES/NO

f. When the crew arrived to commence work was the area clean, prepared, and ready for work to proceed? YES/NO

g. Was the job delayed by any other factor attributable to the general contractor? (if YES,how?) YES/NO

h. Are interactions with other trades normally necessary on this type of job? (if YES,what?) YES/NO

i. Was there any unusual interference from other trades? (if YES,what) YES/NO

j. Were you delayed by material shortages or other problems attributable to your own management's (the firm hiring you) planning? (if YES,what?) YES/NO

k. Were there any delay due to "acts of God?" (if YES,what?) YES/NO

l. What % of footage had to be reworked because it was substandard? ______

m. Describe the cause of rework (if any):

n. What were the most significant problems affecting the work rate on this job?

o. What changes would have improved the work rate?(USE THE BACK IF NECESSARY)

4. Questions for the supervisor if answer to question 3a was YES and if time and convenience exists: (CIRCLE THE CORRECT ANSWER)

a. How often did the supervisor go on the job site? DAILY, EVERY OTHER DAY, EVERY THIRD DAY, LESS OFTEN

b. What % of the entire job was the supervisor on the job site? ________

c. Were the visits announced? YES/NO

d. Were there any delays in the progress of work?(if YES,what?) YES/NO

e. When the crew arrived to commence work was the area clean, prepared, and ready for work to proceed? YES/NO

f. Was the job delayed by any other factor attributable to the general contractor? (if YES,how?) YES/NO

g. Are interactions with other trades normally necessary on this type of job? (if YES,what?) YES/NO

h. Was there any unusual interference from other trades? (if YES, what) YES/NO

i. Were you delayed by material shortages or other problems attributable to your own management's planning? (if YES, what?) YES/NO

j. Were there any delays due to "acts of God?" (if YES, what?) YES/NO

k. What % of footage had to be reworked because it was substandard? _____

l. Describe the cause of rework (if any):

m. What were the most significant problems affecting the work rate on this job?

n. What changes would have improved the work rate?(USE THE BACK IF NECESSARY)

Add the following questions to the basic Productivity Improvement Survey:

1. The number of lineal feet of cut tile (this can be computed from perimeter data if knowledge of how tile area equalized):

2. Change question 3K &4J -- "acts of God" to "weather, storms, or earthquakes"

3. Number of man hours for each of the following items if the time for these was included in total job time of question 1:

   Transporting tile material:

   Laying of stair treads, base or tile:

   Clearing, cleaning, and preparation of surface:

   Installation of floor insulation or other sub-tile material:

4. Was a pre-work planning meeting with General Contractor or coordinating official of Contractors held within one week of work? YES/NO

   within 24 hours of work? YES/NO

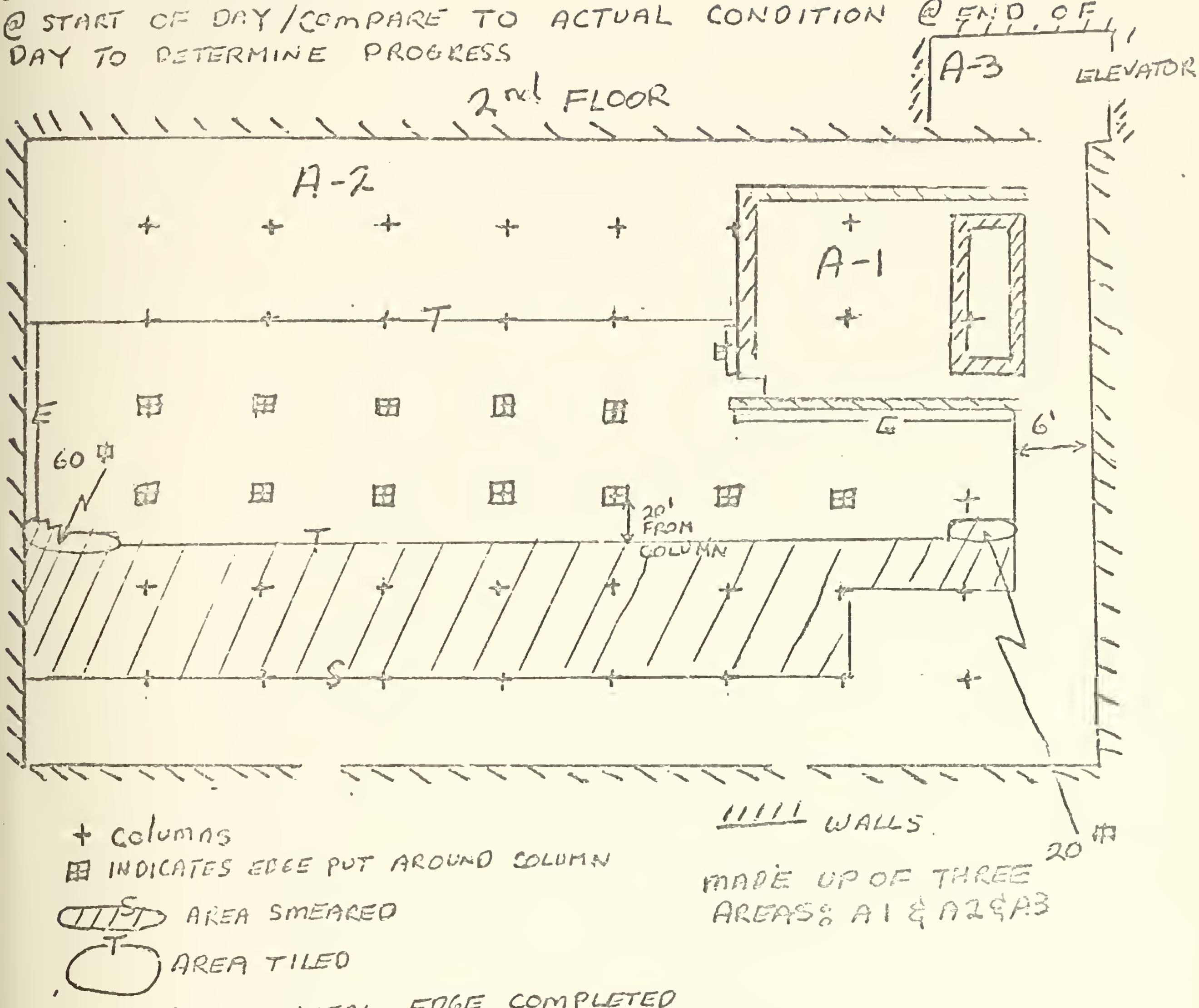
   (Note: include in the term meeting an official business phone call made to coordinate and/or confirm planning schedule and conditions)

5. Was the site inspected within 24 hours prior to crew arrival by staff of subcontractor doing the floor laying? YES/NO

   EXPLAIN PLEASE WHO AND WHAT WAS EXTENT OF INSPECTION, IF YES

B1 SITE CONDITION AND LAYOUT

@ START OF DAY / COMPARE TO ACTUAL CONDITION @ END OF DAY TO DETERMINE PROGRESS



C1 DAILY COMPLETION REPORT

Square feet of adhesive smeared	250
Square feet of field installed	3470
Lineal feet of base installed	—
Lineal feet of edge cut-in	210

APPENDIX D-1

SAMPLE SITE CONDITION AND LAY OUT/DAILY COMPLETION REPORT

APPENDIX D-2

SAMPLE PERSONNEL STATUS/EQUIPMENT AND MATERIAL STATUS

B2 PERSONNEL STATUS

NAME	WORK AREA INITIALLY	TIME ARR @ SITE	START BREAK OUT	COMMENCE WORK	COMMENT
Worker A	—	0720	0734	talking	
Worker B	—	0725	0733	among	
Worker C	—	0725	0733	each other	

B3 EQUIPMENT/TOOLS & BUILDING MATERIALS LOCATION AND STATUS

NAME	STORAGE LOCATION	READY USE AREA	COMMENT
Tiles	A-1	in center of A-2	Transported by cart from A-1 to A-2 and then on dolly or by hand to place needed
Tools	A-3	A-1	During breakout each day the tools are brought to area A-1 and then picked up for used as needed
Adhesive Base	same as tiles A-1 and a third floor storage area		

APPENDIX D-3

SAMPLE PROGRESS LOG

EVENT NO.	TIME START	TIME END	EVENT
1	0734		Worker A calls shop about tile delivery; all others start breaking out tools with Worker C moving tiles
2	0736		Worker A back from call and starts moving tiles onto skids
3	0738		Worker B starts marking off vents
4	0739		Worker C stops moving tiles and starts getting out tools
5	0741		Worker C starts opening tiles
6	0742		Worker A starts loading tiles to the area in which he will lay field
7	0743		Worker A starts laying field
8	0744	0746	Worker B gets a broom and seeps small area around where he is working
9	0747	0748	Worker A in Worker B's way
10	0750	0751	Worker A and Worker B shoot the breeze
11	0755		Worker C starts cleaning the area
12	0759		Worker C prepares tools to start smearing after being informed by Worker A
13	0800		Worker C starts smearing
14	0804	0805	Worker B stops to clean work area
15	0805	0807	Worker C gets more smear
16	0809		Worker C stops smearing and starts moving tiles again
17	0809	0811	Worker A gets more tiles
18	0814	0816	Worker B goes to bathroom
19	0818	0820	Worker B cleans up work area
20	0820	0822	Worker B sharpens tools then etching vents
21	0822	0825	Worker A talking to electrician for a break
22	0826		Worker C starts cleaning up the area
23	0833	0834	Worker B sharpens tools again
24	0835	0838	Worker A stops to get more tiles
25	0836	0837	Worker A coordinates with cement finishers
26	0840	0842	Worker C finishes cleaning up and replaces a broken tile, and goes to edge work
27	0844	0845	Worker B sharpening tools
28	0903	0906	Worker A gets more tile
29	0919	0921	Worker C stops to order coffee from man who takes orders
30	0920	0931	Worker A gets more tiles
31	0931	0936	Worker A and Worker C snap a line
32	0945		Worker C stops cutting edge and measures area to determine how much edge he needs
33	0951	1015	Coffee break for all; after it all return to the same jobs as just before it

P1 PROGRESS LOG

EVENT NO.	TIME START	TIME END	EVENT
34	1020	1024	Worker B stops etching vents and gets tools for edge work; then does edge
35	1025	1026	Worker A talks to electrician — not job related
36	1027	1030	Worker A gets more tiles
37	1050	1054	Worker B goes to bathroom
38	1055	1057	Worker A gets more tiles
39	1055	1113	Worker C goes to third floor to get more base
40	1113	1129	Worker C moving tiles
41	1115		Worker B is continuing edge work
42	1123	1125	Worker A gets more tiles
43	1130		Worker C measuring edge again for determining how much needed
44	1136		Worker B starts using a torch to cut edge
45	1141	1143	Worker C breaks to look at snow
46	1143		All break for lunch
47	1226		Worker A and Worker C go to unload truck that has arrived with tiles; Worker B back to work on edge
48	1230	1240	Worker A and Worker C delayed because truck can not get into driveway due to car blocking it; had to spend time looking for owner
49	1240	1310	Worker A and Worker C delayed because truck is stuck in the snow and they were attempting to help it
50	1250		Worker B stops edge work and starts etching vents again
51	1313	1337	Worker A and Worker C helped unload truck; moving tiles to site
52	1337		Worker A starts laying field again; Worker C continues to move tiles
53	1338		Worker B stops etching work and starts edge work again
54	1339	1340	Worker A stops to talk to a carpenter— non-job related
55	1345		Worker C finishes moving tiles and starts doing edge work again
56	1358	1400	Worker B takes a smoke break
57	1410		Worker C goes for coffee
58	1410	1417	Worker A gets more tile
59	1418	1430	All take coffee break
60	1430		Worker B starts in on field
61	1430	1432	Worker A and Worker C take talk break
62	1432	1437	Worker A and Worker C clean up
63	1437	1447	Worker A calls the home office and

EVENT NO.	TIME START	TIME END	EVENT
			then leaves for the day because of the snow
64	1438	1443	Worker C stops cleaning up and starts on edging
65	1443	1445	Worker B gets more tile
66	1459	1500	Worker B and Worker C interrupted by job superintendent asking questions
67	1502	1510	Worker C starts cleaning up and takes tools to storage
68	1502	1503	Worker B gets more tile
69	1510	1515	Worker C layes field
70	1515	1525	Worker B and Worker C clean up
71	1525		Both men leave

APPENDIX D-4

SAMPLE ACTIVITY/TIME COMPILATION SHEET

ACTIVITY / TIME COMPILATION SHEET

3	5	A
JOB NO.	DAY	WORKMAN

Activity | BRK | HOD | CMT | MBM | IF | BRK | IF | MBM | IF | BRK | IF | MBM |

Time 0720 34 38 42 43 50 51 0809 11 22 25 35 38

Activity | IF | MBM | IF | MBM | LM | IF | BRK | IF | BRK | IF | MBM | IF |

Time 38 0905 06 29 31 38 51 1015 25 26 27 30 55

Activity | MBM | IF | MBM | IF | BRK | MBM | OINT | OINT | MBM | IF | BRK |

Time 55 57 1123 25 48 1226 30 40 1313 37 39 40

Activity | IF | MBM | IF | BRK | BRK | CMT | HOD |

Time 40 1410 17 18 30 32 37 47

Activity

Time

Activity

Time

Activity

Time

Activity

Time

Activity

Time

Activity

Time

Activity

Time

Activity

Time

ABREVIATION	ACTIVITY	TOTAL TIME
—	HOURS PAID	8
OMC	ONSITE MGT/ COORDINATION	0
HOD	HOME OFF. DELAY	.2
OINT	ONSITE INTERF	.7
CMT	CLEANING & MOVE TOOLS/ CLEAN UP	.2
BRK	BREAKS/NON-JOB RELATED ACTIVITY	1.7

ABREIATION	ACTIVITY	TOTAL TIME
MBM	MOVE& PREPBUILD MATERIALS	.9
LM	LAYOUT/MEASURE	.1
SP	SURFACE PREP	.0
IF	INSTALL FIELD	3.6
SA	SHEAR ADHESIVE	.0
IB	INSTALL BASE	.0
IE	INSTALL EDGE	.0

APPENDIX E-1

Job Description for Job #1

This job was an office renovation job at an educational institution. The workmen were Union carpenters who were salaried employees of the institution's maintenance department carpenter shop. They worked out of an office on campus that was separated from the job site by a quarter of a mile. Each day they stopped in at the office to change clothes and punch their time cards both in the morning and evening. Although both supervisor and the men knew how to lay vinyl asbestos tile, none of them had worked as full time tile layers. Their most recent vinyl asbestos tiling job had been two months prior on a repair contract that had taken four hours to complete. The first day of observation was the first day on the job for the workmen. The job site was clean and well-lit. Carpenters, electricians, and painters were also working in the area but created little congestion. All equipment was left on the site overnight. The two workers never talked excessively between themselves even though they seemed to be good friends.

There were no comments from the workers or the observer concerning motivation, management and methods.

SUMMARY SHEET

1				X
Job No.	Day No.	Daily	Weekly	Total

Input Labor Breakdown:	man-hrs	% of total onsite time
Total paid manhours (excluding supervisor's time)	68	100
Labor Utilization Schedule		
Mgt & coordination activity/ Delays		
Onsite mgt & coordination of work(intra crew)	.8	1
Home office caused delays	9.6	14
Unpredictable & onsite interference	.5	1
*Total	10.9	16
Supervisor onsite inspecting & coordinating	.8	1
(not included in work time)		
Leadman on phone coordinating with	.0	0
supervisor (a subset of home office caused delays)		
*Cleaning & moving tools/Clean up of area/	4.4	6
Preparation of tools		
*Breaks & non-job related activity	17.4	26
*Moving & Prep of building materials	4.6	7
*Layout of work/ Measurement of area	1.9	3
*Surface Preparation	1.6	2
Productive work		
Installation of field	4.7	7
Smearing of floor adhesive	4.1	6
Installation of base	8.8	13
Installation of edge	9.5	14
*Total	27.1	40
Total time onsite (excluding supervisor's time; the sum of all * activities)	67.7	100

Labor Output Schedule	
Square feet of adhesive smeared	2270
Sqare feet of field installed	1720
Lineal feet of base installed	535
Lineal feet of edge cut-in	510

SUMMARY SHEET

/	/	X		
Job No.	Day No.	Daily	Weekly	Total

Input Labor Breakdown:

	man-hrs	% of total onsite time
Total paid manhours (excluding supervisor's time)	12	100
Labor Utilization Schedule		
Mgt & coordination activity/ Delays		
Onsite mgt & coordination of work(intra crew)	.0	0
Home office caused delays	1.7	14
Unpredictable & onsite interference	.0	0
*Total	1.7	14
Supervisor onsite inspecting & coordinating	.1	1
(not included in work time)		
Leadman on phone coordinating with	.0	0
supervisor (a subset of home office caused delays)		
*Cleaning & moving tools/Clean up of area/	.6	5
Preparation of tools		
*Breaks & non-job related activity	5.0	42
*Moving & Prep of building materials	1.3	11
*Layout of work/ Measurement of area	1.1	9
*Surface Preparation	.5	4
Productive work		
Installation of field	.0	0
Smearing of floor adhesive	1.7	14
Installation of base	.0	0
Installation of edge	.0	0
*Total	1.7	14
Total time onsite (excluding supervisor's time; the sum of all * activities)	11.9	100

Labor Output Schedule

Square feet of adhesive smeared	730
Sqare feet of field installed	—
Lineal feet of base installed	—
Lineal feet of edge cut-in	—

SUMMARY SHEET

1	2	X		
Job No.	Day No.	Daily	Weekly	Total

Input Labor Breakdown:	man-hrs	% of total onsite time
Total paid manhours (excluding supervisor's time)	16	100
Labor Utilization Schedule		
Mgt & coordination activity/ Delays		
Onsite mgt & coordination of work(intra crew)	.0	0
Home office caused delays	1.7	11
Unpredictable & onsite interference	.2	1
*Total	1.9	12
Supervisor onsite inspecting & coordinating (not included in work time)	.1	1
Leadman on phone coordinating with supervisor (a subset of home office caused delays)	.0	0
*Cleaning & moving tools/Clean up of area/ Preparation of tools	1.4	9
*Breaks & non-job related activity	3.3	21
*Moving & Prep of building materials	.9	6
*Layout of work/ Measurement of area	.4	2
*Surface Preparation	.2	1
Productive work		
Installation of field	2.3	14
Smearing of floor adhesive	.5	3
Installation of base	.0	0
Installation of edge	3.1	19
*Total	7.9	49
Total time onsite (excluding supervisor's time; the sum of all * activities)	16.0	100

Labor Output Schedule

Square feet of adhesive smeared	600
Sqare feet of field installed	670
Lineal feet of base installed	—
Lineal feet of edge cut-in	270

SUMMARY SHEET

Job No.	Day No.	Daily	Weekly	Total
1	3	X		

Input Labor Breakdown:	man-hrs	% of total onsite time
Total paid manhours (excluding supervisor's time)	8	99
Labor Utilization Schedule		
Mgt & coordination activity/ Delays		
Onsite mgt & coordination of work(intra crew)	.2	2
Home office caused delays	.6	7
Unpredictable & onsite interference	.1	1
*Total	.9	11
Supervisor onsite inspecting & coordinating	.0	0
(not included in work time)		
Leadman on phone coordinating with	.0	0
supervisor (a subset of home office caused delays)		
*Cleaning & moving tools/Clean up of area/	.7	9
Preparation of tools		
*Breaks & non-job related activity	1.7	21
*Moving & Prep of building materials	1.0	12
*Layout of work/ Measurement of area	.2	2
*Surface Preparation	.5	6
Productive work		
Installation of field	1.3	16
Smearing of floor adhesive	.3	4
Installation of base	.0	0
Installation of edge	1.1	14
*Total	3.1	38
Total time onsite (excluding supervisor's time; the sum of all * activities)	8.1	100

Labor Output Schedule

Square feet of adhesive smeared	80
Sqare feet of field installed	530
Lineal feet of base installed	—
Lineal feet of edge cut-in	80

SUMMARY SHEET

1	4	X		
Job No.	Day No.	Daily	Weekly	Total

Input Labor Breakdown:	man-hrs	% of total onsite time
Total paid manhours (excluding supervisor's time)	16	98
Labor Utilization Schedule		
Mgt & coordination activity/ Delays		
Onsite mgt & coordination of work(intra crew)	.2	1
Home office caused delays	2.8	17
Unpredictable & onsite interference	.2	1
*Total	3.2	20
Supervisor onsite inspecting & coordinating (not included in work time)	.1	1
Leadman on phone coordinating with supervisor (a subset of home office caused delays)	.0	0
*Cleaning & moving tools/Clean up of area/ Preparation of tools	.7	4
*Breaks & non-job related activity	3.8	23
*Moving & Prep of building materials	.8	5
*Layout of work/ Measurement of area	.2	1
*Surface Preparation	.4	2
Productive work		
Installation of field	.0	0
Smearing of floor adhesive	.9	6
Installation of base	6.0	37
Installation of edge	.3	2
*Total	7.2	44
Total time onsite (excluding supervisor's time; the sum of all * activities)	16.3	100

Labor Output Schedule	
Square feet of adhesive smeared	560
Sqare feet of field installed	—
Lineal feet of base installed	405
Lineal feet of edge cut-in	—

SUMMARY SHEET

/	5	X		
Job No.	Day No.	Daily	Weekly	Total

Input Labor Breakdown:

	man-hrs	% of total onsite time
Total paid manhours (excluding supervisor's time)	16	99
Labor Utilization Schedule		
Mgt & coordination activity/ Delays		
Onsite mgt & coordination of work(intra crew)	.4	2
Home office caused delays	2.8	17
Unpredictable & onsite interference	.0	0
*Total	3.2	20
Supervisor onsite inspecting & coordinating (not included in work time)	.5	3
Leadman on phone coordinating with supervisor (a subset of home office caused delays)	.0	0
*Cleaning & moving tools/Clean up of area/ Preparation of tools	1.0	6
*Breaks & non-job related activity	3.6	22
*Moving & Prep of building materials	.6	4
*Layout of work/ Measurement of area	.2	1
*Surface Preparation	.0	0
Productive work		
Installation of field	1.1	7
Smearing of floor adhesive	.7	4
Installation of base	2.8	17
Installation of edge	2.6	16
*Total	7.2	45
Total time onsite (excluding supervisor's time; the sum of all * activities)	16.1	100

Labor Output Schedule

Square feet of adhesive smeared	300
Sqare feet of field installed	520
Lineal feet of base installed	130
Lineal feet of edge cut-in	160

APPENDIX E-2

Job Description for Job #2

This job was an office renovation project on the eighth floor of a midtown Manhattan printing building as a joint tile and carpet contract. The areas actually tiled were office cubicals, a corridor and two bathrooms with lobbies. The corridor was generally eight feet wide and had closets and various protusions. Other trades were also on the premises including metal and glass workers and electricians as well as the client's representative. The observed job length was two and a half days. The work crew was reduced each succeeding day to prevent overcrowding as the work load was reduced. Management was kept informed of job progress by a daily phone call and random inspections by a field superintendent. Since all men were versatile in both tiling and carpet laying, they could be adjusted to work around delays in each area. The on-site foreman followed the work progress closely and moved men as necessary without hesitation. The tools and materials were stored in an office continguous to the work area. Coffee and lunch items could be purchased on the first floor and elevator service was available for all uses. The subsurfaces were supposed to be ready to receive tile and carpet although as noted extra time was spent to clean up the mess the painters and electricians had left. This particular job had been running about one week but all men working on it had been engaged in continuous employment over the last two months as tile layers. The foreman and men were all aware of profitability requirements of their boss and exhibited a great deal of group cohesion and mutual support. All men considered themselves "shopmen". All tools, as usual,

were the property of the men themselves. All internal environmental conditions were excellent in terms of heat, light, ventilation, and cleanliness.

I. WORKERS' COMMENTS (PARAPHRASED)

A. Motivation

Foreman:

1. I think the motivation is the motivation of being pushed. The boss (home-office) is pushing on many jobs, the crews (different trades) are pushing each other, and often near the end of the month a push is on so tenants can occupy.

2. It makes a big difference if men have worked together. Being a "shopman", not a Union Hall man, makes a big difference. In this town the Union rules allow men to work without going through the Union Hall.

3. I think highly of the men I have working for me.

Workers:

1. The foreman on this job is a very hard worker and we hope that at his age we will be able to work half as well.

2. The foreman is so good because he has been pushing for so long that he is used to it.

3. The quality of the past may be lost and the pride in seeing a building "grow" is not that great a motivation. It is certainly overshadowed by economics. However, we prefer to do quality work when we can.

4. Some 300-400 out of 900 of the local Union tile layers are out of work now in tiling. In this shop we are paid for seven hours per day, but "shopmen" will work over time at no extra pay. If at the end of the day we learn that the work is a must, then we get over time for it but other-

wise it is non-over time work. This is a good set up because if we are a little late in the morning then we stay a little later at the end of the day.

5. Other shops have gotten greater outputs because they used a quota system that was raised in stages. Those shops were willing to sacrifice quality for speed in the hopes that they would not get hit with a replacement cost. They are used to the pace.

B. Management

Office Contact:

1. This is a good shop because the men don't pilfer any material. The owner has agreed to sell them material without the five percent profit mark-up.

Foreman:

1. A possible difference between the U.S. and other places in the world is that in the U.S. we work several trades on top of each other whereas in other countries often they will not work of other trades are in their way who may mess up their work. The price in the U.S. is to have to clean new carpet or tile when it is only one month old because other workmen have trampled on it, but the work finishes on time.

2. The pension system is paid by the employer through the Union. A tile layer has to work a minimum of 100 hours every six months for 15 years till 55 years old to get the minimum benefit and the maximum benefits comes after working 25 years till 65 years old. There is also an annuity program through the Union that the employer pays.

3. In order to get in the Union one must work in a Union shop for six months, then apply if the books are open. Then there is an initiation if you are taken and you become an apprentice.

4. If the boss does not make money, we are out of business and it is a nickel and dime business -- very competitive. I do not know the bid cost of the job but I work to come under the deadline that the boss sets for me.

5. Management looks at a job months before it is actually run and must bid it before knowing all the job requirements.

6. The newest man in the shop came in six years ago.

7. Eight man hours were lost on this job the previous week due to the management's failure to confirm that the storage area was open on a weekend.

8. Straight Union Hall help is not as "push conscious".

9. All men are paid the same even though the rules say that the foreman should get one hour more. We don't mind the rules being bent a little so that there is steady work.

10. The boss figures that with the office backup and benefits that he must pay to vacations, social security, etc., that our time is worth $17 per hour.

11. There are no tile cutting machines on the job because there is very little straight base or edge and it is just as fast to score and break the tiles anyway.

<u>Workers:</u>

1. This job is typical for the amount of clean up and preparation of floor surfaces needed.

C. Technical

Foreman:

1. You need to use asphalt tile for radiant heat floor because expanding and contracting will shrink vinyl asbestos tile.

2. We often call tile manufacturers and describe the job before using an adhesive that might work. It is a good general practice because then if anything fails there is someone to blame.

II. COMMENTS OF THE OBSERVER:

1. There was a definite team spirit among all these men.

2. The foreman made daily completion reports by phone at the end of the work day. Other coordination problems were worked out at this time.

3. Unfortunately, as with all the jobs observed, there was no way of knowing how much work would be rejected. Some companies work very fast and have to pay a premium for it later.

4. Workmen appeared to set arbitrary goals for work completion (e.g. finishing a room before "knocking off").

5. Management should know the current job status of all jobs in order to shift or anticipate shifting men as an incentive for leadman to meet completion dates by utilizing workers when they are available.

6. One advantage of laying carpet and tile with the same men is the ability to shift men when delays in one activity occur.

7. Workmen talked about various general contractors throughout the city. Apparently the attitude and reputation of various higher level managers reached the ranks and had a definite affect on the preparatory set of the workmen going into a job (e.g. "You know which guys you can fool").

8. It appeared that the boss's knowledge of the tiling business directly affected the men's trust. Where they thought he know what he was doing, they not only avoided taking advantage of him, they also seemed to take pride in working for him.

9. In very tight areas (e.g. closets) it was time consuming and tiring to lay tiles.

10. The reason tiles were not installed on wet smear was because the tiles could slide out of position if walked on soon after they were laid.

11. Production was forced up when management took a man off the job. This occurred even though the foreman said that he needed the man to finish on time. This seemed to be a subtle way for management to improve productivity. Foremen eventually learn that they must use their men effectively or lose them without a corresponding drop in output expectations.

12. These men were specialists in finished flooring.

13. Enthusiasm dropped off as a man was pulled off the job. Teams of men appeared to keep up a pace and when a man left it disturbed the pace.

14. By being on the job site for three or more days an observer gains an appreciation of the workmen and job conditions.

15. The quality of work seemed to drop off slightly in order to finish on the final day.

16. The leadman kept track of the man hours each man worked and reported results to his supervisor for payroll records.

17. These men were profit oriented and felt that by helping their boss stay in business they ensured steady work for themselves.

18. The men helped each other more when management stated that the job must finish on time.

19. All workers observed were married with a house of their own.

20. The employer had possible control over Union workers' pay by offering steady employment in return for active work at regular wages.

SUMMARY SHEET

2				X
Job No.	Day No.	Daily	Weekly	Total

Input Labor Breakdown:

	man-hrs	% of total onsite time
Total paid manhours (excluding supervisor's time)	22.5	95
Labor Utilization Schedule		
Mgt & coordination activity/ Delays		
Onsite mgt & coordination of work(intra crew)	1.4	6
Home office caused delays	.8	3
Unpredictable & onsite interference	.3	1
*Total	2.5	10
Supervisor onsite inspecting & coordinating (not included in work time)	.6	3
Leadman on phone coordinating with supervisor (a subset of home office caused delays)	.4	2
*Cleaning & moving tools/Clean up of area/ Preparation of tools	2.7	11
*Breaks & non-job related activity	3.3	14
*Moving & Prep of building materials	1.1	5
*Layout of work/ Measurement of area	.1	0
*Surface Preparation	2.7	11
Productive work		
Installation of field	.9	4
Smearing of floor adhesive	1.2	5
Installation of base	.0	0
Installation of edge	9.3	39
*Total	11.4	48
Total time onsite (excluding supervisor's time; the sum of all * activities)	23.8	100

Labor Output Schedule

Square feet of adhesive smeared	870
Sqare feet of field installed	770
Lineal feet of base installed	—
Lineal feet of edge cut-in	420

SUMMARY SHEET

2	1	X		
Job No.	Day No.	Daily	Weekly	Total

Input Labor Breakdown:	man-hrs	% of total onsite time
Total paid manhours (excluding supervisor's time)	5.5	100
Labor Utilization Schedule		
Mgt & coordination activity/ Delays		
Onsite mgt & coordination of work(intra crew)	.5	9
Home office caused delays	.3	5
Unpredictable & onsite interference	.0	0
*Total	.8	14
Supervisor onsite inspecting & coordinating (not included in work time)	.0	0
Leadman on phone coordinating with supervisor (a subset of home office caused delays)	.4	7
*Cleaning & moving tools/Clean up of area/ Preparation of tools	1.0	18
*Breaks & non-job related activity	.6	11
*Moving & Prep of building materials	.2	4
*Layout of work/ Measurement of area	.0	0
*Surface Preparation	.1	2
Productive work		
Installation of field	.3	5
Smearing of floor adhesive	.2	4
Installation of base	.0	0
Installation of edge	2.3	42
*Total	2.8	51
Total time onsite (excluding supervisor's time; the sum of all * activities)	5.5	100

Labor Output Schedule	
Square feet of adhesive smeared	220
Sqare feet of field installed	260
Lineal feet of base installed	—
Lineal feet of edge cut-in	180

SUMMARY SHEET

2	2	X		
Job No.	Day No.	Daily	Weekly	Total

Input Labor Breakdown:

	man-hrs	% of total onsite time
Total paid manhours (excluding supervisor's time)	7	93
Labor Utilization Schedule		
Mgt & coordination activity/ Delays		
Onsite mgt & coordination of work(intra crew)	.1	1
Home office caused delays	.0	0
Unpredictable & onsite interference	.2	3
*Total	.3	4
Supervisor onsite inspecting & coordinating (not included in work time)	.3	4
Leadman on phone coordinating with supervisor (a subset of home office caused delays)	.0	0
*Cleaning & moving tools/Clean up of area/ Preparation of tools	.8	11
*Breaks & non-job related activity	1.4	19
*Moving & Prep of building materials	.5	7
*Layout of work/ Measurement of area	.0	0
*Surface Preparation	.3	4
Productive work		
Installation of field	.3	4
Smearing of floor adhesive	.4	5
Installation of base	.0	0
Installation of edge	3.5	47
*Total	4.2	56
Total time onsite (excluding supervisor's time; the sum of all * activities)	7.5	100

Labor Output Schedule

Square feet of adhesive smeared	350
Sqare feet of field installed	310
Lineal feet of base installed	—
Lineal feet of edge cut-in	240

SUMMARY SHEET

2	3	X		
Job No.	Day No.	Daily	Weekly	Total

Input Labor Breakdown:	man-hrs	% of total onsite time
Total paid manhours (excluding supervisor's time)	10	93
Labor Utilization Schedule		
Mgt & coordination activity/ Delays		
Onsite mgt & coordination of work(intra crew)	.8	7
Home office caused delays	.5	5
Unpredictable & onsite interference	.1	1
*Total	1.4	13
Supervisor onsite inspecting & coordinating (not included in work time)	.3	3
Leadman on phone coordinating with supervisor (a subset of home office caused delays)	.0	0
*Cleaning & moving tools/Clean up of area/ Preparation of tools	.9	8
*Breaks & non-job related activity	1.3	12
*Moving & Prep of building materials	.4	4
*Layout of work/ Measurement of area	.1	1
*Surface Preparation	2.3	21
Productive work		
Installation of field	.3	3
Smearing of floor adhesive	.6	6
Installation of base	.0	0
Installation of edge	3.5	32
*Total	4.4	41
Total time onsite (excluding supervisor's time; the sum of all * activities)	10.8	100

Labor Output Schedule	
Square feet of adhesive smeared	300
Sqare feet of field installed	200
Lineal feet of base installed	—
Lineal feet of edge cut-in	150

APPENDIX E-3

Job Description for Job #3

This job consisted of laying tiles in open bays on two floors. There were approximately sixty-three 21 foot by 21 foot bays on each floor. The concrete subsurface was prepared by an independent subcontractor and was proceeding just ahead of the tile installation. Custodial services were provided if refuse was moved into the elevator landing area contiguous to the work area. Although the tiling subcontractor supplied his men with an hydraulic hand lift and extra skids for tiles, all tools were provided by the men themselves. The leadman received feedback on the quality of the crew's work after job completion. The shop was a Union shop with over 25 years experience. Each bay had two 72 inch by 18 inch floor air vent outlets to provide cooling air for future electronic computers. Only a portion of each vent was left open. Removable plates were installed over a portion of the outlet so as to conform to the projected computer layout. This scheme permitted shifts in the computer layout. Tiles were cut to fit neatly over the plates to allow for changes in the vent configuration with a minimum of destruction to the existing floor. In order to avoid cutting each tile around these plates, a template was made and used as a guide to etch the tile along the plate after the field was laid. Needless to say, it took longer to lay tile because marks for the template had to be marked and cut. The same process occurred on Job #4 around vent plates. The perimeter had numerous pipe ducts that required time consuming edge and base work. The job had run one month before the observer arrived. All men, however, had been working continuously in tiling for several months before the job had started. The environment

was clean, warm, and well lit.

I. WORKERS' COMMENTS (PARAPHRASED)

A. Motivation

Office Contact:

1. It is hard to say why productivity is up but it is related to competition in a trade that has no seniority and good pay.

Foreman:

1. Tile layers are used to working alone because unless there is pressure from the general contractor to add extra men, there is no need for more than a few men on the job site.

2. Economics now control motivation.

3. Up bringing but not education affects motivation.

4. It is a matter of personally setting daily goals so that I think in terms of finishing and not starting a job.

5. I am just motivated to do my best every day.

6. In Union jobs you don't have the right to push men too hard especially if you are out of your home jurisdiction. In the same shop, men work harder. This is ruining the trade because everyone wants a steady job and we are becoming shopmen more than Union men.

7. The Union apprentices are taught to push and speed whereas this does not exist in non-Unions.

8. I can lead a man by example if he is slow by putting him next to me and telling him to keep up.

Workers:

1. There is a need for continuous work to support family or debts, and if I don't produce I am out. Since labor knows that management knows how long a job should take, the pace is kept up.

2. Working together before helps but what helps more is the knowledge that I am working with a good crew.

3. Working for the same supervisor helps but more than that is having capable people who know exactly what the job is so that I am working with experienced people who don't have to run up to the leadman asking simple questions about technical things.

4. It is the years of experience being pushed, and the expectation.

5. Anything that is measured in square footage can be controlled. Electricians, for example, cannot and probably have the worst productivity.

B. Management

Office Contact:

1. Material handling makes a big difference.

2. This job is going well, but I would not tell the men that.

Foreman:

1. Slowness of cement finishers forced a less efficient manpower utilization of the tile layers.

2. General and "subs" argue, lie, and play games constantly to shift pressure and blame.

3. In this shop, it is a practice of laying off apprentices as soon as they become mechanics since apprentices have full time work, and tend to get used to that. This layoff is only temporary but serves to remind the journeyman that he must earn his keep. One man that had escaped this sort of treatment gave the leadman some trouble.

4. Unions don't really train you better in their apprenticeship program. It is the experience that counts. The Unions only screen out people who do not want to be in the Union by forcing them through the program.

5. In this shop, there is a wasteful practice that occasionally occurs although not on this job. The shop requires that people stop in at the office prior to going on the job to pick up job orders and do menial work at the shop. They should increase their material delivery service to six men from one and have the increased delivery personnel clean and straighten the office when necessary.

6. You can get bulk skid boxes of tiles already open which saves many man hours in cutting open boxes of tiles, and clean up. They had been ordered on this job but were not delivered as such in bulk.

7. Superintendents for the general contractor may try to cheat me by directing me somewhere that is not indicated on the job order.

8. This entire job could have been ruined because an addendum to a change order was not sent to the leadman on the job.

<u>Workers</u>:

1. Unions now require technical aptitude tests prior to entering.

2. Non-Union shops don't do big jobs because they aren't as specialized and have different production quotas.

3. We could work faster if we all worked field then did edges and then base, because of the effect of competition but the quality would be poorer due to "runs".

C. Technical

Foreman:

1. A good floor job won't have "runs" or "swings" in the line.

2. The type of tile manufacturer makes a different in speed. The polished tile is easier to handle and slides in place easier. With poor tile your fingers can start bleeding from having to force tiles in place to prevent "runs". Also, the better quality tiles resist stains better and are easier to clean if someone spills coffee on them.

3. Two types of cement should be sent out on a job. One should be fast drying in case extra people are sent on the job or if I am forced to work in one area. This is in addition to the slower setting emulsion.

4. Soft trowels wear down too fast, and mechanics must have the skill to sharpen trowels and knives properly.

5. It may not be good for two men to be laying field in the same room because they will create "runs".

Workers:

1. Tile laying is very physical work.

2. If I put tiles on wet concrete and then add weight the tiles will spread apart.

3. I can't put down tile if it is too cold. The floor and tiles should be stored together in the same space for 24 hours at 24 degrees F prior to laying.

4. There can be real shrinkage problems with tiles laid in the sun.

5. The type of torch head makes a big difference in hot work.

II. COMMENTS OF OBSERVER:

1. The influence of a hard worker (to bolster the sense of being on a winning team) seemed (undocumented) to have a positive effect.

2. Unexpected delays whether management or otherwise, had a demoralizing effect on the routine and morale.

3. It appeared that certain men were conscientious regardless of external motivation.

4. Music with a fast pace helped only if good supervision and leadership were present too. The music helped people relax but was not necessary if something equally effective had been provided.

5. A good measure of rate could monitor and control productivity.

6. Economic depressions and competition for work seemed to improve labor productivity.

7. In interviewing, it was important to give the foreman a written letter of intent. There was some questioning later in the week concerning the use of the data, even though a complete examination was given earlier in the week.

8. In interviewing, it was not a good idea to discuss how other shops worked.

9. All men were on a first name basis.

10. Foreign countries will need more than U.S. technology. They will need the same or an equivalent institutional, educational, and social background to drive the pace of the work.

11. It was important to motivate people through a chain of command that could convey demands and enforce discipline.

12. Sudden changes and layoffs required construction workers to own their own car.

13. Each man worked with the tools with which he felt comfortable.

SUMMARY SHEET

3				X
Job No.	Day No.	Daily	Weekly	Total

Input Labor Breakdown:

	man-hrs	% of total onsite time
Total paid manhours (excluding supervisor's time)	128	98
Labor Utilization Schedule		
Mgt & coordination activity/ Delays		
Onsite mgt & coordination of work(intra crew)	2.5	2
Home office caused delays	3.1	2
Unpredictable & onsite interference	2.0	2
*Total	7.6	6
Supervisor onsite inspecting & coordinating (not included in work time)	.5	0
Leadman on phone coordinating with supervisor (a subset of home office caused delays)	.8	1
*Cleaning & moving tools/Clean up of area/ Preparation of tools	11.4	9
*Breaks & non-job related activity	25.2	19
*Moving & Prep of building materials	8.3	6
*Layout of work/ Measurement of area	2.3	2
*Surface Preparation	7.1	5
Productive work		
Installation of field	16.6	13
Smearing of floor adhesive	6.6	5
Installation of base	33.5	26
Installation of edge	11.9	9
*Total	68.6	53
Total time onsite (excluding supervisor's time; the sum of all * activities)	130.5	100

Labor Output Schedule

Square feet of adhesive smeared	12730
Sqare feet of field installed	11030
Lineal feet of base installed	1730
Lineal feet of edge cut-in	730

SUMMARY SHEET

3	1	X		
Job No.	Day No.	Daily	Weekly	Total

Input Labor Breakdown:	man-hrs	% of total onsite time
Total paid manhours (excluding supervisor's time)	30	99
Labor Utilization Schedule		
Mgt & coordination activity/ Delays		
Onsite mgt & coordination of work(intra crew)	.6	2
Home office caused delays	1.3	4
Unpredictable & onsite interference	.6	2
*Total	2.5	8
Supervisor onsite inspecting & coordinating (not included in work time)	.3	1
Leadman on phone coordinating with supervisor (a subset of home office caused delays)	.0	0
*Cleaning & moving tools/Clean up of area/ Preparation of tools	4.1	14
*Breaks & non-job related activity	7.1	24
*Moving & Prep of building materials	.4	1
*Layout of work/ Measurement of area	1.2	3
*Surface Preparation	1.2	3
Productive work		
Installation of field	.0	0
Smearing of floor adhesive	3.1	10
Installation of base	7.7	25
Installation of edge	2.9	10
*Total	13.7	45
Total time onsite (excluding supervisor's time; the sum of all * activities)	30.2	100

Labor Output Schedule	
Square feet of adhesive smeared	5540
Sqare feet of field installed	0
Lineal feet of base installed	490
Lineal feet of edge cut-in	190

SUMMARY SHEET

3	2	X		
Job No.	Day No.	Daily	Weekly	Total

Input Labor Breakdown:	man-hrs	% of total onsite time
Total paid manhours (excluding supervisor's time)	26	93
Labor Utilization Schedule		
Mgt & coordination activity/ Delays		
Onsite mgt & coordination of work(intra crew)	.8	3
Home office caused delays	1.6	6
Unpredictable & onsite interference	.0	0
*Total	2.4	9
Supervisor onsite inspecting & coordinating	.2	1
(not included in work time)		
Leadman on phone coordinating with	.6	2
supervisor (a subset of home office caused delays)		
*Cleaning & moving tools/Clean up of area/	3.4	12
Preparation of tools		
*Breaks & non-job related activity	3.8	14
*Moving & Prep of building materials	1.7	6
*Layout of work/ Measurement of area	.4	1
*Surface Preparation	.7	3
Productive work		
Installation of field	1.2	4
Smearing of floor adhesive	.0	0
Installation of base	14.4	51
Installation of edge	.0	0
*Total	15.6	56
Total time onsite (excluding supervisor's time; the sum of all * activities)	28.0	100

Labor Output Schedule	
Square feet of adhesive smeared	0
Sqare feet of field installed	670
Lineal feet of base installed	670
Lineal feet of edge cut-in	5

SUMMARY SHEET

3	3	X		
Job No.	Day No.	Daily	Weekly	Total

Input Labor Breakdown:

	man-hrs	% of total onsite time
Total paid manhours (excluding supervisor's time)	24	96
Labor Utilization Schedule		
Mgt & coordination activity/ Delays		
Onsite mgt & coordination of work(intra crew)	.7	3
Home office caused delays	.0	0
Unpredictable & onsite interference	.1	0
*Total	.8	3
Supervisor onsite inspecting & coordinating	.0	0
(not included in work time)		
Leadman on phone coordinating with	.0	0
supervisor (a subset of home office caused delays)		
*Cleaning & moving tools/Clean up of area/	1.7	7
Preparation of tools		
*Breaks & non-job related activity	4.2	17
*Moving & Prep of building materials	1.4	6
*Layout of work/ Measurement of area	.2	1
*Surface Preparation	.4	2
Productive work		
Installation of field	5.5	22
Smearing of floor adhesive	1.7	7
Installation of base	6.6	27
Installation of edge	2.4	8
*Total	16.2	65
Total time onsite (excluding supervisor's time; the sum of all * activities)	24.9	100

Labor Output Schedule

Square feet of adhesive smeared	3720
Sqare feet of field installed	2460
Lineal feet of base installed	450
Lineal feet of edge cut-in	80

SUMMARY SHEET

3	4	X		
Job No.	Day No.	Daily	Weekly	Total

Input Labor Breakdown:

	man-hrs	% of total onsite time
Total paid manhours (excluding supervisor's time)	24	101
Labor Utilization Schedule		
Mgt & coordination activity/ Delays		
Onsite mgt & coordination of work(intra crew)	.0	0
Home office caused delays	.0	0
Unpredictable & onsite interference	.0	0
*Total	.0	0
Supervisor onsite inspecting & coordinating	.0	0
(not included in work time)		
Leadman on phone coordinating with	.0	0
supervisor (a subset of home office caused delays)		
*Cleaning & moving tools/Clean up of area/	.9	4
Preparation of tools		
*Breaks & non-job related activity	5.1	21
*Moving & Prep of building materials	2.0	8
*Layout of work/ Measurement of area	.3	1
*Surface Preparation	1.4	6
Productive work		
Installation of field	5.5	23
Smearing of floor adhesive	1.7	7
Installation of base	4.8	20
Installation of edge	2.1	9
*Total	14.1	59
Total time onsite (excluding supervisor's time; the sum of all * activities)	23.8	100

Labor Output Schedule

Square feet of adhesive smeared	3220
Sqare feet of field installed	4430
Lineal feet of base installed	110
Lineal feet of edge cut-in	250

SUMMARY SHEET

3	5	X		
Job No.	Day No.	Daily	Weekly	Total

Input Labor Breakdown:	man-hrs	% of total onsite time
Total paid manhours (excluding supervisor's time)	24	102
Labor Utilization Schedule		
Mgt & coordination activity/ Delays		
Onsite mgt & coordination of work(intra crew)	.4	2
Home office caused delays	.2	1
Unpredictable & onsite interference	1.3	6
*Total	1.9	8
Supervisor onsite inspecting & coordinating (not included in work time)	.0	0
Leadman on phone coordinating with supervisor (a subset of home office caused delays)	.2	1
*Cleaning & moving tools/Clean up of area/ Preparation of tools	1.3	6
*Breaks & non-job related activity	5.0	21
*Moving & Prep of building materials	2.8	12
*Layout of work/ Measurement of area	.2	1
*Surface Preparation	3.4	14
Productive work		
Installation of field	4.4	19
Smearing of floor adhesive	.1	0
Installation of base	.0	0
Installation of edge	4.5	19
*Total	9.0	38
Total time onsite (excluding supervisor's time; the sum of all * activities)	23.6	100

Labor Output Schedule	
Square feet of adhesive smeared	250
Sqare feet of field installed	3470
Lineal feet of base installed	—
Lineal feet of edge cut-in	210

APPENDIX E-4

Job Description for Job #4

This job was located in New York City in new office construction. The job was observed for four days and had a varying work crew from five to eight men. A portion of one day was spent moving tile via an elevator to the floor level. A specific feature of this job was the requirement to cut in edges around vent plates at various locations in the center of large areas (similar to Job #3). Men laying field had to open each box of tile individually after taking it from a wheeled cart of tiles located centrally about fifteen feet away. The job had been running about one week prior to being observed, but all men had had continuous work for the previous two months in tiling.

The field supervisor came on the job site every day but the last. He knew each man individually and stayed on the site for nearly one hour. He spent most of his time with the foreman, however, and was free with pointed remarks concerning possible loss of productivity. All the men knew each other and had many common friends. Socializing seemed to be an important part of each day as the men regularly arrived 15 minutes early to sit around and talk until eight o'clock when work started. Coffee orders as well as lunch orders would be taken by the junior man at these morning sessions so that time would not be wasted later. The environment was well lighted but the ventilation was poor and several men brought throat lozenges. There was little congestion with other trades.

I. WORKERS' COMMENTS (PARAPHRASED)

A. Motivation

Foreman:

1. I get a target cost for labor and can request changes in the labor force to meet that cost but am given no incentive for making them.

2. I receive $.75 more an hour than the other mechanics plus paid holidays. For some it really is not much of a bonus for the headache involved. There are three guys who are regular foremen and get foremen privileges even if not working as one on a job.

Workers:

1. The pace is something I am used to. I have pride in the fact that I have never been laid off and have been working hard at this for 18 years.

2. I get used to the quota and expectation.

3. I am working for the boss and he has to make money.

4. I do it for the money. I work at night after this job is over so I never have to worry about a budget. My family and I take a trip every year to Puerto Rico and I like to have spending money for poker games. In addition, I like to get a new car each year.

5. You have to have the calluses on your fingers and knees that are used to the work, but most of it is a mental attitude of not being defeated and able to do any job.

6. Survival along with greed is my motivation. This trade is not typical of all building trades because there is very little chance for pride in workmanship due to the high expectation and quota.

7. It is all in how you break in the new workers.

8. The regional differences in wage do not affect productivity at all.

9. This shop brought productivity up over 18 years by giving supervisors bonuses for higher productivity when their crew out-performed other crews during a given month. This drove the rate up and it became the expectation. Now a bonus is no longer needed.

10. In other trades there is pride in your work because it has to be done right. In tiling it does not have to be exactly right like electrical wiring.

11. It just depends on the worker; the pace he is used to, and his practice.

B. Management

Foreman:

1. These are nearly perfect conditions. You will not find much better (this was before their loading problems).

2. First few days of a job, everybody's around then you do not see them for a while.

Workers:

1. Both cutback and emulsion are on the job site so we can work with faster drying emulsion if necessary.

2. It normally takes one hour to unload a truck like the one that took us all morning because of elevator problems and broken unloading tracks.

C. Technical -- none.

II. COMMENTS OF OBSERVER:

1. Several boxes of tile and a push cart were stolen and it took time to look for it.

2. The foreman used the phone a great deal to iron out problems with material supplier.

3. Lunch was held up one day because the leadman felt the job was behind.

4. Tiles were laid cold after being brought in from freezing weather. The warming tiles caused expansion problems in laid field and had to be corrected.

5. The loading truck supplied by the tile wholesaler came with three broken rollers and held up the unloading process considerably. In addition, it was late and had to wait for a garbage truck to load before tiles could be taken through the one door leading to the construction site.

6. Elevators had problems only once. Coincidentally, it was while the tiles were being brought up.

7. It appeared that the effort to push crews could be successful if quality could be afforded.

8. Pushing is another case of how the job is made to fit the estimate rather than vice versa.

9. The unseen value of a good leadman shows up in the planning and organizing of the work plus the ability to accurately lay out the work.

10. Several of the faster tile layers were in high school athletic programs.

11. A key to high productivity is in conditioning people who are willing to work at a high pace.

12. Money becomes a means of extending social respect beyond the work group.

13. There was a lot of waste due to vandalism when materials sat around on a building site.

14. The supervisor paced around like a task master every day, used strong language with the foreman and men, but talked to each man individually.

SUMMARY SHEET

4				X
Job No.	Day No.	Daily	Weekly	Total

Input Labor Breakdown:	man-hrs	% of total onsite time
Total paid manhours (excluding supervisor's time)	175	93
Labor Utilization Schedule		
Mgt & coordination activity/ Delays		
Onsite mgt & coordination of work(intra crew)	5.4	3
Home office caused delays	5.5	3
Unpredictable & onsite interference	3.3	2
*Total	14.2	7
Supervisor onsite inspecting & coordinating	3.5	2
(not included in work time)		
Leadman on phone coordinating with	.0	0
supervisor (a subset of home office caused delays)		
*Cleaning & moving tools/Clean up of area/	8.2	4
Preparation of tools		
*Breaks & non-job related activity	35.4	19
*Moving & Prep of building materials	32.3	17
*Layout of work/ Measurement of area	5.1	3
*Surface Preparation	2.2	1
Productive work		
Installation of field	38.6	20
Smearing of floor adhesive	18.7	10
Installation of base	.0	0
Installation of edge	32.8	17
*Total	90.1	48
Total time onsite (excluding supervisor's time; the sum of all * activities)	187.5	100

Labor Output Schedule

Square feet of adhesive smeared	43370
Sqare feet of field installed	45230
Lineal feet of base installed	—
Lineal feet of edge cut-in	1900

SUMMARY SHEET

4	1	X		
Job No.	Day No.	Daily	Weekly	Total

Input Labor Breakdown:	man-hrs	% of total onsite time
Total paid manhours (excluding supervisor's time)	35	96
Labor Utilisation Schedule		
Mgt & coordination activity/ Delays		
Onsite mgt & coordination of work(intra crew)	1.2	3
Home office caused delays	.5	1
Unpredictable & onsite interference	.2	0
*Total	1.9	5
Supervisor onsite inspecting & coordinating (not included in work time)	1.2	3
Leadman on phone coordinating with supervisor (a subset of home office caused delays)	.0	0
*Cleaning & moving tools/Clean up of area/ Preparation of tools	1.7	5
*Breaks & non-job related activity	6.0	16
*Moving & Prep of building materials	3.6	10
*Layout of work/ Measurement of area	1.5	4
*Surface Preparation	.0	0
Productive work		
Installation of field	7.9	22
Smearing of floor adhesive	4.1	11
Installation of base	.0	0
Installation of edge	9.8	27
*Total	21.8	60
Total time onsite (excluding supervisor's time; the sum of all * activities)	36.5	100

Labor Output Schedule	
Square feet of adhesive smeared	7360
Sqare feet of field installed	9840
Lineal feet of base installed	–
Lineal feet of edge cut-in	740

SUMMARY SHEET

4	2	X		
Job No.	Day No.	Daily	Weekly	Total

Input Labor Breakdown:	man-hrs	% of total onsite time
Total paid manhours (excluding supervisor's time)	42	93
Labor Utilization Schedule		
Mgt & coordination activity/ Delays		
Onsite mgt & coordination of work(intra crew)	1.4	3
Home office caused delays	1.5	3
Unpredictable & onsite interference	.0	0
*Total	2.9	6
Supervisor onsite inspecting & coordinating (not included in work time)	1.2	3
Leadman on phone coordinating with supervisor (a subset of home office caused delays)	.0	0
*Cleaning & moving tools/Clean up of area/ Preparation of tools	2.0	4
*Breaks & non-job related activity	9.0	20
*Moving & Prep of building materials	4.6	10
*Layout of work/ Measurement of area	1.6	4
*Surface Preparation	.5	1
Productive work		
Installation of field	10.9	24
Smearing of floor adhesive	5.8	13
Installation of base	.0	0
Installation of edge	7.6	17
*Total	24.3	54
Total time onsite (excluding supervisor's time; the sum of all * activities)	44.9	100

Labor Output Schedule	
Square feet of adhesive smeared	12[illegible]00
Sqare feet of field installed	10[illegible]0
Lineal feet of base installed	—
Lineal feet of edge cut-in	54[illegible]

SUMMARY SHEET

4	3	X		
Job No.	Day No.	Daily	Weekly	Total

Input Labor Breakdown:	man-hrs	% of total onsite time
Total paid manhours (excluding supervisor's time)	56	93
Labor Utilization Schedule		
Mgt & coordination activity/ Delays		
Onsite mgt & coordination of work(intra crew)	1.9	3
Home office caused delays	3.5	6
Unpredictable & onsite interference	2.9	5
*Total	8.3	14
Supervisor onsite inspecting & coordinating (not included in work time)	1.1	2
Leadman on phone coordinating with supervisor (a subset of home office caused delays)	.0	0
*Cleaning & moving tools/Clean up of area/ Preparation of tools	2.3	4
*Breaks & non-job related activity	11.4	19
*Moving & Prep of building materials	17.2	29
*Layout of work/ Measurement of area	.5	1
*Surface Preparation	1.7	3
Productive work		
Installation of field	6.3	10
Smearing of floor adhesive	3.7	6
Installation of base	.0	0
Installation of edge	8.6	14
*Total	18.6	31
Total time onsite (excluding supervisor's time; the sum of all * activities)	60.0	100

Labor Output Schedule	
Square feet of adhesive smeared	10810
Sqare feet of field installed	6760
Lineal feet of base installed	—
Lineal feet of edge cut-in	640

SUMMARY SHEET — 4 Job No. · 4 Day No. · X Daily · Weekly · Total

Input Labor Breakdown:	man-hrs	% of total onsite time
Total paid manhours (excluding supervisor's time)	42	91
Labor Utilisation Schedule		
Mgt & coordination activity/ Delays		
Onsite mgt & coordination of work(intra crew)	.9	2
Home office caused delays	.0	0
Unpredictable & onsite interference	.2	0
*Total	1.1	2
Supervisor onsite inspecting & coordinating	.0	0
(not included in work time)		
Leadman on phone coordinating with	.0	0
supervisor (a subset of home office caused delays)		
*Cleaning & moving tools/Clean up of area/	2.2	5
Preparation of tools		
*Breaks & non-job related activity	9.0	20
*Moving & Prep of building materials	6.9	15
*Layout of work/ Measurement of area	1.5	3
*Surface Preparation	.0	0
Productive work		
Installation of field	13.5	29
Smearing of floor adhesive	5.1	11
Installation of base	.0	0
Installation of edge	6.8	15
*Total	25.4	55
Total time onsite (excluding supervisor's time; the sum of all * activities)	46.1	100

Labor Output Schedule

Square feet of adhesive smeared	12600
Sqare feet of field installed	17670
Lineal feet of base installed	—
Lineal feet of edge cut-in	880

APPENDIX E-5

Job Description for Job #5

This job was a renovation project in Midtown Manhattan. The layout was one of corridors and offices in a high rise office building. Elevators provided the only form of transporting personnel and material to the site location on the seventh floor. All rip out had been completed and cleaned up and the renovation was being carried out by electricians, carpenters, painters, wall paperers, carpet and tile layers. The presence of the general contractor's staff, the client, their architects, and laborers on-site created congestion in several parts of the floor. The tiling was done by one person and consisted of placing standard tiles and coved base in elevator lobbies, and toeless base in the corridors. No field supervision showed up on-site during the period and the only accountability was in the form of a phone call to the home-office at the end of the work day. Additional work such as the preparation of the floor surface, was also required. Building materials could be stored within 20 yards of the work area during most of the work. The environment was clean, well lit, and comfortably heated. A coffee cart came to the floor in the morning and afternoon as well as at lunch time (indicating to some extent when breaks were taken). Although in an on-off manner, the job had been running several weeks as a one man operation at the general contractor's discretion, to avoid interference. At the completion of the observation several man days of work remained, but no more than a week for one man, barring complications. Due to a material oversight by the management, coved base that was toeless to be used with carpet in the corridors was

not sent to the job site and regular base had to be hand-stripped of its toe. This lead to poor workmanship and extra work. The sole worker was a mechanic with many years experience in tiling with one year left before retirement. He had been continuously working for at least two months previous to this job.

I. WORKERS' COMMENTS (PARAPHRASED)

A. Motivation

Worker:

1. I like to work at a steady even pace and not rush in the afternoon to make up the difference if it goes slow in the morning.

2. In very productive shops the foreman can get a lot out of his men, but then he is not liked.

3. I am afraid that there will be too many call backs on this job, and it will be my last with the shop.

4. After you have been working awhile, the only motivation is money and the pride in work is gone with the demands for speed.

B. Management

Worker:

1. Cost savings from non-Union work rates are not passed onto the owner. They are going into the contractor's pockets.

2. I should have a torch for hot work on edge but I am all out of propane gas. This holds me up somewhat.

3. I am being held up by the laborers not cleaning the area before me and the wallpaper hangers who are too slow. The general contractor's superintendent was told about the problem, but still only supplies two

laborers on a job that needs more.

4. With the "right to work" act, a job cannot legally be declared Union only although the Union may strike if the job is not. However, if the Union does, it only hurts the Union men because other men can be hired.

5. Union business agents are paid off to bend rules so that more apprentices can go on the job than are required.

6. One fast shop has fast crews that do repetitious work and special crews with better mechanics for renovation and more careful work.

7. Materials handling is a big issue, and on several jobs has cost much time. On short jobs it is especially pronounced when you have to wait for tile to arrive on the job site.

8. It might be nice to rotate foremen on the jobs but some workers don't like to be foremen (leadman), because of the responsibility to push people.

C. Technical

<u>Worker</u>:

1. A good technique for quickly laying out a floor that saves time in installing edge is to lay out the field so that one side has six inches between the field and the boundary wall if the boundary is straight. Then one can cut two pieces of 12 inch tile at one time when fitting edge.

2. Smearing the wall directly for application of base is faster but may be messier as adhesive may get on the floor. If the base is to be used with a rug then this will be all right.

3. Pure vinyl tiles show all imperfections and can never have a smooth surface.

4. Curback adhesive is good if it can be spread the day before. Otherwise it takes too long to dry.

II. COMMENTS OF THE OBSERVER

1. There were differences in the break time depending on the coffee truck location.

2. At one point, a worker could have gotten in another 30 minutes of work towards the end of the day, but he stopped early due to having finished a room.

3. Although the workman had worked for the same shop for the last six years, his loyalty to the shop appeared limited.

4. The worker's self-esteem needs were filled at home much more than at the job (apparently) and the job was just a matter of economic security to support that home.

5. Since the worker had no propane, he was scori[illegible] and breaking tiles along the score to fit in edges.

6. Unexpected job obstructions are a part of eac[illegible] job. However, experienced workers knew how to anticipate and wor[illegible] around them.

7. The installation of loud speakers could have helped job coordination.

8. Workers' anticipation of coffee breaks often slowed down their working rate minutes before.

SUMMARY SHEET

5				X
Job No.	Day No.	Daily	Weekly	Total

Input Labor Breakdown:	man-hrs	% of total onsite time
Total paid manhours (excluding supervisor's time)	14	94
Labor Utilization Schedule		
Mgt & coordination activity/ Delays		
Onsite mgt & coordination of work(intra crew)	.4	3
Home office caused delays	.8	5
Unpredictable & onsite interference	.6	4
*Total	1.8	12
Supervisor onsite inspecting & coordinating (not included in work time)	.0	0
Leadman on phone coordinating with supervisor (a subset of home office caused delays)	.2	1
*Cleaning & moving tools/Clean up of area/ Preparation of tools	1.4	9
*Breaks & non-job related activity	3.9	26
*Moving & Prep of building materials	.9	6
*Layout of work/ Measurement of area	.0	0
*Surface Preparation	.6	4
Productive work		
Installation of field	.7	5
Smearing of floor adhesive	.4	3
Installation of base	3.8	25
Installation of edge	1.4	9
*Total	6.3	42
Total time onsite (excluding supervisor's time; the sum of all * activities)	14.9	100

Labor Output Schedule	
Square feet of adhesive smeared	550
Sqare feet of field installed	450
Lineal feet of base installed	575
Lineal feet of edge cut-in	120

SUMMARY SHEET

5	1	X		
Job No.	Day No.	Daily	Weekly	Total

Input Labor Breakdown:	man-hrs	% of total onsite time
Total paid manhours (excluding supervisor's time)	7	95
Labor Utilization Schedule		
Mgt & coordination activity/ Delays		
Onsite mgt & coordination of work(intra crew)	.2	3
Home office caused delays	.4	5
Unpredictable & onsite interference	.5	7
*Total	1.1	15
Supervisor onsite inspecting & coordinating (not included in work time)	.0	0
Leadman on phone coordinating with supervisor (a subset of home office caused delays)	.1	1
*Cleaning & moving tools/Clean up of area/ Preparation of tools	.9	12
*Breaks & non-job related activity	1.7	23
*Moving & Prep of building materials	.4	5
*Layout of work/ Measurement of area	.0	0
*Surface Preparation	.6	8
Productive work		
Installation of field	.7	9
Smearing of floor adhesive	.4	5
Installation of base	.2	3
Installation of edge	1.4	19
*Total	2.7	36
Total time onsite (excluding supervisor's time; the sum of all * activities)	7.4	100

Labor Output Schedule	
Square feet of adhesive smeared	550
Sqare feet of field installed	450
Lineal feet of base installed	15
Lineal feet of edge cut-in	120

SUMMARY SHEET

5	2	x		
Job No.	Day No.	Daily	Weekly	Total

Input Labor Breakdown:	man-hrs	% of total onsite time
Total paid manhours (excluding supervisor's time)	7	93
Labor Utilization Schedule		
Mgt & coordination activity/ Delays		
Onsite mgt & coordination of work(intra crew)	.2	3
Home office caused delays	.4	5
Unpredictable & onsite interference	.1	1
*Total	.7	9
Supervisor onsite inspecting & coordinating (not included in work time)	.0	0
Leadman on phone coordinating with supervisor (a subset of home office caused delays)	.1	1
*Cleaning & moving tools/Clean up of area/ Preparation of tools	.5	7
*Breaks & non-job related activity	2.2	29
*Moving & Prep of building materials	.5	7
*Layout of work/ Measurement of area	.0	0
*Surface Preparation	.0	0
Productive work		
Installation of field	.0	0
Smearing of floor adhesive	.0	0
Installation of base	3.6	48
Installation of edge	.0	0
*Total	3.6	48
Total time onsite (excluding supervisor's time; the sum of all * activities)	7.5	100

Labor Output Schedule	
Square feet of adhesive smeared	0
Sqare feet of field installed	0
Lineal feet of base installed	560
Lineal feet of edge cut-in	—

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